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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIII.—No. 2924.] *LONDON: FRIDAY, JANUARY 13, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
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ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement pages 27 and 73.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 9179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 9389

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9109

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 7411
See Advertisement last week, page 97.

S. Sokal, CHARTERED PATENT AGENT.
1, Great James Street, Bedford Row, London, W.C.1.
T.N. 4515 Museum. 9675

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9105

Cochran Boilers. MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 9109

Petter Oil Engines.
For Paraffin and Crude Oil.
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.

Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Oct 9783

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD.. 9350
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of 1834
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.3.

Iron and Steel
Tubes and Fittings.
Sole Licencees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 77, Jan. 6.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9563
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Oct 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

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LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
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Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL.
NAVAL OUTFITS A SPECIALITY, also for Merchant Ships, and Factories, and Industrial Process Furnaces of all kinds. 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Oct 2487
See their Illus. Advertisement, page 103, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS. MOTHERWELL. Oct 3383

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Oct 8353
3, VICTORIA STREET, WESTMINSTER, S.W.

Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS for
ENGINEERING AND ALLIED TRADES and
INDUSTRIAL PROPERTIES. 9866
63 and 64, CHANCERY LANE, LONDON, W.C.2.

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London."
—Great Eastern Road, Stratford, E.15. 1704

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28, 1921.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 9364
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 84. 9091

Economy!
HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS.
49-51, EASTCHEAP, LONDON, E.C. 3.
TODD SHIPYARDS CORPORATION,
Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways.
26, Broadway, New York, U.S.A.

Electric Cranes.
Traversers.
Transporters.
Lifts.
S. H. HEYWOOD & Co., LTD., Reddish.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9054

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Oct3382

The National Foremen's
ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.
(Registered under the Trade Union Act.)
An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. F 601
All communications to— H. W. REID, General Secretary. Head Offices— 96, Belgrave Road, Victoria, London, S.W.1.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } ROWS PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Yarrow Patent Water-tube Boilers. 9564
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9518
See Full Page Advt., page 69, Jan. 6.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.
E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
306, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7424. Oct 585

Taylor & Challen Presses 8195
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement page 68, Jan. 6.

FOR
Drop Forgings write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9074

"Spencer-Hopwood" Patent WATER TUBE **Boilers.** *See page 82.* 9293
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

GRAPHITED OIL. **"OILDAG"** (Reg.) BRAND.
GRAPHITED WATER. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE. **"GREDAG"** 9505

E. G. Acheson Ltd.,
Dept. E., (Sole Manufacturers.) 40, WOOD ST., S.W.1. Works: PLYMOUTH.

Spur & Bevel Gear Generating
ATTACHMENTS FOR SHAPERS.
Spur Gear 12 in. Straight & Spiral Bevels 6 in. and 9 in. Through Merchants only. 9704
MATTHERSON, LIMITED, Shawclough, Rochdale.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Oct 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W.1.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9727
See half-page Advertisement page 75, Dec. 23.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

Leeds University.

DEPARTMENT OF COAL GAS AND FUEL INDUSTRIES (WITH METALLURGY).
SPECIAL COURSES OF EVENING LECTURES will be given during JANUARY, FEBRUARY, AND MARCH, on
I. THE MANUFACTURE OF COAL GAS, by Dr. H. G. Colman, D.Sc., Ph.D., F.I.C.
Ia. RECORDING GAS CALORIMETERS, by Mr. J. W. Wood, M.Sc., A.I.C.
II. REFRACTORY MATERIALS, by Professor J. W. Cobb, C.B.E., B.Sc., F.I.C.
III. METALLURGY, by Mr. P. F. Summers, A.R.S.M.
The Laboratory will be open on Wednesday Evenings for students desiring instruction in Fuel Calorimetry and Pyrometry.
For further information apply to THE REGISTRAR, The University, Leeds. T 72

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9206

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9814

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Experienced London Coaches

Prepare successfully for the B.Sc., and the Engineering Institution Examinations. Personal or correspondence tuition. Only a limited number of pupils taken.—Address, T 93, Offices of ENGINEERING.

TENDERS.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of :—

1. Screws, Iron and Brass, for wood.
2. Copper Tubing.
3. Copper Wire.
4. Brass Boiler Tubes.
5. Vertical Boilers.
6. Laminated Springs.
7. Tyres, Steel, Engine.

Forms of Tender may be obtained from the Director-General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Tuesday, the 31st January, 1922, for Nos. 1 to 3, and on Tuesday, the 7th February, 1922, for Nos. 4 to 7.

T. RYAN,
T 120 Director-General.

Tenders are Invited by

the GOVERNMENT of NEW SOUTH WALES for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of a CANTILEVER BRIDGE ACROSS SYDNEY HARBOUR from DAWES POINT to MILSON'S POINT, embracing a main span of 1600 ft. in the clear, centre to centre of main piers, or 2000 ft. centre to centre of anchor piers. The total length of bridge included in tender is 3816 ft., centre to centre of abutments. The deck of the bridge is to include four lines of railway, and a roadway 57 ft. wide, between main trusses; and cantilevered outside the main trusses on the western side, a footway 15 ft. wide, and on the eastern side a motor roadway 18 ft. wide. Copies of specification, including plans, general conditions, and schedule of quantities may be obtained on application to the undersigned.

To give any information required by Tenderers, Mr. J. J. C. Bradfield, Chief Engineer, will be in London during June and July, 1922, address care of the undersigned.

Tenders in accordance with the specification must reach the Under Secretary for Public Works, Sydney, not later than 31st October, 1922.

AGENT-GENERAL,
FOR NEW SOUTH WALES.
Australia House, Strand, London, W.C. 2.
December, 1921. T 34

METROPOLITAN ASYLUMS BOARD.

The Metropolitan Asylums Board invite

Tenders for the Covering of

HOT WATER and HEATING PIPES, CALORIFIERS, &c., with Non-conducting Composition, at the North-Western Fever Hospital, Lawn Road, Hampstead, N.W. 3, in accordance with Drawing and Specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.

The Drawing, Specification and Form of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m., on Monday, 16th January, 1922, and the Drawing, Specification and Form of Tender may then be obtained upon payment of a deposit of £1.

The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender, and after the Drawing and Specification have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 1st February, 1922.

By Order,
T 131 DUNCOMBE MANN,
Clerk to the Board.

CORPORATION OF DURBAN, NATAL.

The Corporation of Durban, Natal, is prepared to receive

Tenders for the Supply and

DELIVERY "Free on Board" British Port, of :—

One 20-ton HAND OPERATED OVERHEAD TRAVELLING CRANE, to be approved by the Representative Engineers, Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, S.W.

Specification to be obtained from, and sealed and endorsed Tenders must be delivered to the undersigned on or before 31st January, 1922.

The lowest or any Tender will not necessarily be accepted.

Applications for Specifications must be accompanied by a deposit of two guineas per copy, which sum will be refunded on receipt of bona fide Tender.

By Order,
WEBSTER, STEEL & CO.,
5, East India Avenue,
Leadenhall Street,
London, E.C.
Agents to the Durban Corporation. T 127

LONDON COUNTY COUNCIL.

Tenders are Invited for the

MANUFACTURE, SUPPLY, DELIVERY and MAINTENANCE of FOUNDRY PLANT for the Council's Tramways Central Repair Depot.

The Specification, Form of Tender and other particulars may be obtained from the Clerk of the Council, County Hall, Spring Gardens, S.W. 1., on payment to the Cashier of the Council of a deposit of £2, which amount will be refunded on receipt of a *bona fide* Tender. Particulars of the work may be obtained on application at the County Hall before payment of this fee.

The drawing referred to in the specification can be inspected by appointment with the General Manager, L.C.C. Tramways, 23, Belvedere Road, S.E. 1., on production of a copy of the specification or a signed receipt for the fee paid in respect thereof.

Tenders must be addressed to the Clerk of the Council and delivered at the County Hall, Spring Gardens, S.W. 1., not later than 12 noon, on Tuesday, 31st January, 1922. No Tender received after that time will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
T 108 Clerk of the London County Council.

MANCHESTER CORPORATION WATERWORKS.

THIRLMERE AQUEDUCT—4TH PIPE LINE.

The Waterworks Committee invite

Tenders for the Laying and

JOINTING of 54 inch WELDED STEEL, and other PIPES, the Fixing of Valves and Ironwork, the Construction of Subways under Railways, etc., and other work connected with the FOURTH PIPE LINE from THIRLMERE to MANCHESTER, as follows :—

CONTRACT "A." Ambleside to South of Kendal (about 8½ miles).
CONTRACT "B." Kirkby Lonsdale to Lancaster (about 8½ miles).
CONTRACT "C." South of Lancaster to River Ribble (about 4½ miles).
CONTRACT "D." River Ribble to Horwich (about 6½ miles).

Printed Specifications, schedules of Quantities, and forms of Tender, may be obtained on application to the Secretary, Waterworks Offices, Town Hall, Manchester, on receipt of a deposit of Five Guineas for each contract, which will only be returned to the tenderer provided that he shall have sent in a *bona fide* Tender, and shall have returned the documents lent to him. Plans and Drawings may be inspected on application to the Waterworks Engineer. Only a limited number of the drawings being available, these, excluding ordnance maps, will be lent to persons tendering in priority of application, on payment of the sum of Three Guineas, which sum will not be returned.

Sealed Tenders, endorsed as directed in the schedules, must be delivered at the Waterworks Offices, Town Hall, Manchester, not later than the 9th of February, 1922.

By Order,
THOMAS HUDSON,
Town Hall, Manchester, Town Clerk.
20th December, 1921. T 8

CORPORATION OF CALCUTTA.
WATERWORKS EXTENSIONS CONTRACTS, 1921.

The Corporation of Calcutta are prepared to receive

Tenders for :—

CONTRACTS I to VI, consisting of the SUPPLY and LAYING in a prepared trench of THIRTY MILES OF RIVETED STEEL PIPE in the following sizes :—60 in., 54 in., 51 in., 48 in., 42 in., 36 in., and 33 in.

Plans can be seen and copies of Specification, Tender, etc., obtained on or after January 20th, 1922 :—

IN ENGLAND, from the Consulting Engineers, Messrs. ST. GEORGE-MOORE & LA TROBE-BATEMAN, M.M.Inst.C.E., 91, Victoria Street, Westminster, S.W. 1, and
IN INDIA, from J. R. COATS, Esq., B.Sc., M.Inst.C.E., Chief Engineer to the Corporation of Calcutta, Central Municipal Offices, Calcutta.

The sum of £5 or Rs. 75 respectively, will be charged for each set of four copies of the contract documents, which sum will be returned on receipt of a *bona fide* Tender, prepared in triplicate.

Two copies of all Tenders, from wherever emanating, to be delivered at the offices of the Consulting Engineers in London, at or before Twelve noon, on March 16th, 1922, when they will be officially opened in the presence of such Tenderers as care to attend. The third copy to be despatched by registered post on or before the same date, addressed to the Chief Engineer, Corporation of Calcutta, Central Municipal Offices, Calcutta.

Tenders to be in sealed covers and superscribed "Corporation of Calcutta, Tender for Steel Mains."

The Corporation do not bind themselves to accept the lowest or any Tender.

Tenderers may submit separate Tenders for alternative proposals.

B. V. RAMIAH,
Secretary to Corporation.
Calcutta,
January, 1922. T 102

SIAM STATE RAILWAYS.

NOTICE.

Tenders are Invited for the

SUPPLY of ACCESSORIES for GOODS ROLLING STOCK.

Specifications and Drawings may be obtained against payment of £2 from Messrs. C. P. SANDBERG, 40, Grosvenor Gardens, London, S.W. 1.

Sealed Tenders, with the inscription "Tender for the Supply of Accessories for Goods Rolling Stock, 2464," must be forwarded to the undersigned, at whose office in the city of Bangkok, Siam, they will be received up to Two p.m. on the 10th day of April, 1922, at which place and hour the Tenders will be publicly opened and read.

Right is reserved to reject any or all Tenders and to accept any Tender which in the opinion of the undersigned is to the best interests of the Siam State Railways.

PURACHATRA,
Commissioner-General of State Railways.
Department of State Railways,
Bangkok,
5th December, 1921. T 114

THE BARNOLDSWICK URBAN DISTRICT COUNCIL invite

Tenders for the Supply,

DELIVERY and ERECTION of a STEAM TRAVELLING CRANE, with 40 ft. jib, to handle loads up to two tons.

Also include in Tender for the Supply, Delivery, and Fixing of 80 ft. of RAILS, to be laid on the ground complete with Sleepers, and the whole to be left ready for use. Date to be stated.

Tender due 18th January, 1922.

J. W. THOMPSON,
Engineer & Manager. T 24

WINCANTON RURAL DISTRICT COUNCIL.

TEMPLECOMBE WATER SUPPLY
CONTRACT No. 2.

The above Council invite

Tenders for the Supply and

ERECTION of PUMPING PLANT in connection with the above Works at the proposed Pumping Station situated at Milborne Wick in the County of Somerset.

The Plant comprises Oil Engine and three throw well pump, together with the necessary head gear, pump rods, &c., complete, capable of raising 6,000 gallons of water per hour to a height of about 220 feet, the whole to be in accordance with the Specification prepared by the Engineers, Messrs. A. P. I. COTTERELL & EDSON, of 17, Old Queen Street, Westminster, S.W. 1.

Copies of the Plans and Specification, and Form of Tender, &c., may be obtained from the Engineers on or after the 16th January, 1922, by intending Contractors on payment of the sum of Two Guineas, which will be returned on receipt of a *bona fide* Tender and all other documents supplied.

Tenders on the Form provided enclosed in sealed envelopes must be delivered to the undersigned and endorsed "Templecombe Water, Contract No. 2," not later than ten a.m., on the 6th February, 1922.

Contractors will be required to provide securities for the due performance of the Contract under Section 174 (4) of the Public Health Act, 1875.

The Council do not undertake to accept the lowest or any Tender, but reserve freedom of action.

By Order,
E. N. MARTIN,
Clerk to the Rural District Council.
Wincanton, Somerset.
7th January, 1922. T 97

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of :—

1. STEEL BEARING PLATES.
2. SCREW SPIKES.
3. LAMPS AND GLASS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Steel Bearing Plates," or as the case may be, must be left with the undersigned not later than Twelve noon, on Wednesday, the 25th January, 1922.

The Directors do not bind themselves to accept the lowest or any tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specifications Nos. 1, 2 and 3.

Copies of the drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

W. B. REYNOLDS,
for Managing Director.
91, Petty France, S.W. 1.
11th Jan., 1922. T 146

LONDON COUNTY COUNCIL.

HAMMERSMITH PUMPING STATION.

Tenders are Invited for the

CONSTRUCTION of an ENGINE HOUSE in brick and concrete with slate roof, internal dimensions 150 ft. by 50 ft. by 40 ft. high to the eaves partly above and partly below ground, with Office, Store, Workshop, and cooling Water Tank, together with Supply, Suction and Delivery Culverts within the building and Foundations for Engines, Pumps and auxiliary Machinery, also the construction of three Penstock Chambers outside the building with connecting Culvert and other subsidiary works. The work will be situated in the Metropolitan Borough of Hammersmith.

Persons desiring to Tender may obtain the Drawings, Specifications, bills of quantities, form of tender, etc., on application to the Chief Engineer at 19, Charing Cross Road, W.C. 2, upon payment to the Cashier of the Council of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and other contract documents may be inspected before the payment of the fee.

No Tender received after Twelve noon on Tuesday, 7th February, 1922, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
T 116

APPOINTMENTS OPEN.

UNIVERSITY OF HONG KONG.

Two Lecturers in Mechanical

Engineering are REQUIRED for the University of Hong Kong. Five years' agreement: salary £500 per annum, converted for purposes of local payment at 2s. to the dollar, free quarters or allowance of £100, half salary from date of embarkation. Candidates should be graduates in Engineering of some British University and preferably unmarried.

Applications should be submitted in covers marked "C.A.," and addressed to the SECRETARY, BOARD OF EDUCATION, Whitehall, London, S.W. 1. Scottish candidates should apply to the SECRETARY, SCOTTISH EDUCATION DEPARTMENT, Whitehall, London, S.W. 1. T 68

LOUGHBOROUGH COLLEGE.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc., D.I.C., Principal.

Wanted, an Additional

INSTRUCTOR in Pattern Making (General Engineering).

It is essential that candidates shall be of good general education and wide general practical experience.

Salary £250 to £260 per annum.

Applications must be made on the prescribed form, copies of which may be obtained from the PRINCIPAL of the College, to whom they must be returned not later than Wednesday, the 25th January, 1922. T 150

UNIVERSITY OF LONDON.

Notice is Hereby Given, that

the Senate will proceed to elect EXTERNAL EXAMINERS for the Examinations above Matriculation as follows. Except when otherwise stated, Examiners will act in all examinations in which the subject occurs. Where Examiners are to be appointed for (a) Intermediate Examinations only and (b) Final and Higher Examinations only, the fact is indicated after the name of the subject below.

FOR THE SESSION 1922-23.

EXAMINATIONS OTHER THAN MEDICAL.

Agricultural Engineering.
Surveying. (Intermediate, One.)
Urban Public Sanitation.
Theory and Principles of the Valuation of Land and Buildings.

FOR THE CALENDAR YEAR 1922.

Engineering, Civil and Mechanical. (Two.)
Engineering, Drawing and Design. (Intermediate, One.)

N.B.—Attention is drawn to the provision of Statute 124, whereby the Senate is required, if practicable, to appoint at least one Examiner who is not a Teacher of the University.

Application Form (or Forms if more than one Examinership is applied for) and particulars of the remuneration and duties can be obtained from the External Registrar.

Candidates must send in their names to the External Registrar, GEO. F. GOODCHILD, M.A., B.Sc., with any attestation of their qualifications they may think desirable, on or before Monday, 23rd January, 1922. (Envelopes should be marked "Examinership.")

It is particularly desired by the Senate that no application of any kind be made to its individual members.

If testimonials are submitted, three copies at least of each should be sent. Original testimonials should not be forwarded in any case. If more than one Examinership is applied for, a separate complete application, with copies of testimonials, if any, must be forwarded in respect of each.

H. C. PERRY,
Principal Officer.
University of London,
South Kensington, S.W. 7.
January, 1922. T 89

CORPORATION OF CALCUTTA.

APPOINTMENT OF EXECUTIVE ENGINEER, DRAINAGE.

Applications are Invited for

the POST of EXECUTIVE ENGINEER, Drainage, Calcutta. The salary of the appointment inclusive of all allowances is Rs. 1300 rising to Rs. 1500 per month by annual increments of Rs. 50. The person appointed will be required to keep a motor car. The cost of a motor car will, if desired, be advanced by the Corporation and recovered in monthly instalments spread over three years.

The appointment is subject to the Provident Fund, Leave and other service rules of the Corporation and may be terminated at any time by six months' notice on either side. The Provident Fund contribution is 8¼ per cent. of the monthly salary and an equivalent amount is contributed by the Corporation and the fund accumulates at compound interest. The selected candidate will be under the direction of the Chief Engineer and be required to devote his whole time to the duties of his office and will not be allowed to take up any private work. He must reside in Calcutta. He will be liable to removal during the term of his office for misconduct or neglect of, or incapacity for his duties. He will be required to submit to a medical examination before joining his appointment. The Corporation will pay his passage (first class) from London to Calcutta, but he must refund the amount so paid, if he gives notice anytime within two years from the date of taking up his appointment. He will be required to take up his appointment within two months of receiving notice of appointment and will receive half pay for the period occupied by the journey.

(a) Preference will be given to candidates who are Members or Associate Members of the Institute of Civil Engineers or Graduates in Engineering of a University, and have had experience in the design, construction and maintenance of sewerage projects for large cities including pipe and masonry sewers, Pumping Stations, sewage treatment and disposal, as well as road and general construction works.

(c) Candidates are to state their age and experience.

(d) Applications will be received in the United Kingdom up to Monday, the 30th January, 1922, by W. C. EASTON, Esq., B.Sc., M.I.C.E., 149, West George Street, Glasgow, from whom any other information concerning the conditions of service, etc., may be obtained.

B. V. RAMIAH,
Secretary to the Corporation.
Central Municipal Office,
8th December, 1921. T 15

THE PROPORTIONING OF STEAM TURBINE BLADING.

By HAROLD MEDWAY MARTIN, Wh.Sc., A.C.G.I.

(*Continued from page* 3.)

IN the preceding article a method was explained of determining, from the stop valve and condenser data and the steam rate required, the thermodynamic head under which a proposed turbine will operate. In illustration of the method a particular case was considered and certain additional data deduced. These will apply to turbines of all sizes and speeds of revolution operating under the same conditions and at the same steam rate. They are collected together below :—

TABLE III.

Stop valve pressure, 250 lb. per square inch (gauge).
Stop valve temperature, 300 deg. C.
Vacuum in condenser, 29 in.
Steam rate, 10·41 lb. per indicated kilowatt hour.
Corresponding hydraulic efficiency, 0·75.
Absolute pressure below governor valve $p_1 = 238$ lb. per square inch.
Specific volume of steam below governor valve $V_1 = 2{\cdot}493$ cub. ft. per lb.
Initial total heat, $H_1 = 728{\cdot}19$ ft-lb. Centigrade units.
Thermodynamic head expended down to saturation line, $U^1 = 107{\cdot}53$ F.P.C.
Absolute pressure at saturation line $p_s = 30$ lb. per square inch.
Total heat at saturation line, $H_s = 647{\cdot}54$ F.P.C.
Specific volume at saturation line, $V_s = 13{\cdot}74$ cub. ft.
Absolute pressure at exhaust, $p_e = 0{\cdot}491$ lb. per square inch.
Total heat at exhaust, $H_e = 545{\cdot}79$ F.P.C.
Specific volume at exhaust, $V_e = 526{\cdot}0$ cub. ft. per lb.

For the purposes of design it is necessary to know, either implicitly or explicitly, corresponding values of U and V at a number of intermediate points beyond those given in the table. So long as the expansion is not carried beyond the supersaturation limit, or Wilson line, we have perfectly definite and exact relationships between p and V, and from values of p and V we could deduce by Callendar's rational formulas corresponding values of H, and thence obtain the value of U, the thermodynamic head expended down to any point of the expansion. It is, however, very much more convenient and sufficiently exact to utilise, for the end in view, formulas of interpolation rather than the more complicated rational expressions.

Callendar has shown that in any expansion the relationship between the total heat of the steam and its specific volume can be estimated with remarkable accuracy by assuming that :

$$\log (H - C) = \log A + \mu \log p \quad . \quad . \quad (1)^*$$

where C is chosen, so that :

$$\frac{H_1 - C}{H_2 - C} = \frac{p_1 V_1}{p_2 V_2}$$

From which, by an obvious transformation, we get :

$$H_1 - C = \frac{p_1 V_1 (H_1 - H_2)}{p_1 V_1 - p_2 V_2}$$

In making practical use of equation (1) it is generally quite unnecessary to determine the constants A and μ.

Let us adopt this formula of interpolation between the initial pressure and the saturation line.

In this case we have :

$$p_1 V_1 = 238{\cdot}0 \times 2{\cdot}493 = 593{\cdot}43.$$
$$p_s V_s = 30 \times 13{\cdot}74 = 412{\cdot}20.$$

whence :

$$p_1 V_1 - p_s V_s = 181{\cdot}14.$$

Moreover,

$$H_1 - H_s = 80{\cdot}65$$

so that :

$$H_1 - C = \frac{593{\cdot}34 \times 80{\cdot}65}{181{\cdot}14} = 264{\cdot}14$$

and thus :

$$C = 464{\cdot}05 \text{ and } H_2 - C = 183{\cdot}49.$$

As a matter of fact, so long as the steam is not wet the value of C is always very nearly equal to 464·00, and accordingly for such expansions Callendar commonly assumes C to be 464·00 instead of calculating it.

If we know values of H — C we can at once determine the corresponding values of U from the equation :

$$U = \frac{H_1 - H}{\eta} = \frac{H_1 - C}{\eta} - \frac{H - C}{\eta}.$$

Now since by the interpolation formula represented by equation (1) $\log (H - C)$ is a linear function of $\log p$, so also is $\log \frac{H - C}{\eta}$. Hence we can very rapidly and simply tabulate corresponding values of the two. To this end we find the value of

$$\log \frac{H_1 - C}{\eta} - \log \frac{H_s - C}{\eta}$$

and also that of

$$\log p_1 - \log p_s.$$

Taking one-tenth of each of these differences, and subtracting it repeatedly from the initial value of $\log \frac{H_1 - C}{\eta}$ or from $\log p$, as the case may be, we get corresponding values of the two functions as tabulated below. A check on the accuracy of the work is provided by the fact that the tenth substraction must give us in the one case the known value of $\log \frac{H_s - C}{\eta}$ and in the other the known value of $\log p_s$. In making repeated subtraction and divisions of this kind it is convenient to write the subtrahend on the lower edge of a scrap of paper and bring it over each successive figure in turn.

TABLE IV.—*Corresponding Values of the Pressure, Volume, and Thermodynamic Head.*

Point.	$\log p$.	$\log \frac{H - C}{\eta}$	$\frac{H - C}{\eta}$	$U = \frac{H_1 - H}{\eta}$	$\log V$.	V.
A	2·37660[6]	2·54680	352·2	0·0	0·39670	2·493
B	2·28665[3]	2·53098	339·6	12·6	0·47083	2·957
C	2·19670[7]	2·51516	327·5	24·7	0·54496	3·507
D	2·10675[3]	2·49934	317·5	36·5	0·61909	4·160
E	2·01680[8]	2·48352	305·5	46·7	0·69322	4·934
F	1·92685[4]	2·46770	293·6	58·6	0·76735	5·799
G	1·83690[1]	2·45188	283·1	69·1	0·84148	6·942
H	1·74695[4]	2·43606	273·0	79·2	0·91561	8·234
I	1·65700[1]	2·42024	263·2	89·0	0·98974	9·766
J	1·56705[6]	2·40442	253·7	98·5	1·06387	11·58
K	1·47710	2·38860	244·7	107·5	1·13800	13·74

The intermediate logarithms in the above table have been taken out to five figures in order to utilise the check already described, but only four figures are significant. If, in compiling this table, we had aimed at making U increase by equal increments, the arithmetical work would have been greatly complicated and the practical advantage nil.

In determining the values of V given in the above table, use was made of the general relation :

$$d U = -\frac{d H}{\eta} = -\frac{144}{J} . V \, d p.$$

From which we get :

$$V = -\frac{144}{\eta J} \cdot \frac{d H}{d p}$$

But on differentiating the interpolation formula (1) we get :

$$\frac{d H}{H - C} = \mu \cdot \frac{d p}{p}$$

whence

$$\frac{d H}{d p} = \mu \frac{H - C}{p}.$$

so that

$$V = \frac{144 \, \mu}{J \eta} \cdot \frac{H - C}{p}.$$

Since μ and η are both constants and $\log (H - C)$ is a linear function of $\log p$, we note that $\log V$ must also be so. Hence we can interpolate values of $\log V$ in the above table by successive additions to $\log V_1$ of one-tenth the difference between $\log V_1$ and $\log V_s$. A check is again provided by the fact that at the last addition we must get $\log V_s$.

Table IV gives the pressure and volume at corresponding sections of a turbine working under the conditions premised, and as K is directly proportional to U, we can also get at once values of K corresponding to these pressures and volumes.

It may be observed that it is not strictly true that $\log (H - C)$ can be expressed as a linear function of p nor can $\log V$., but the errors are more or less compensatory, so that even in extreme cases the discrepancy between the values of U and V thus found are insufficient to be of practical importance. This is well shown in an example worked out in Callendar's "Properties of Steam."* In this case wet steam was assumed to be expanded in thermal equilibrium from a pressure of 165 lb. absolute to 1 lb. absolute with a constant hydraulic efficiency equal to 0·555. The figures below show the values of V as found by the interpolation formulas and the corresponding values of V as determined by exact methods :—

Value of V by formula ..	4·075	6·102	9·278	14·34	22·57	36·22	59·21	99·10
True value of V	4·094	6·113	9·278	14·32	22·52	36·11	59·06	99·10

It will be seen that even in this somewhat extreme case the errors are quite unimportant from the practical standpoint. We may thus take it that the corresponding values of U and V in Table IV above and Table V below are substantially exact, but there is some small error in the corresponding values of p. This, however, is of very little practical importance, because the number of rows of blading and the blade heights depend wholly on U and V and not at all on p.

It may be added that though intermediate values of $\log V$ and of $\log (H - C)/\eta$ have been tabulated above and also in Table V below, it is not in general necessary for the purposes of design to make these tabulations, the initial and final values being all that are required, but the theory of the method to be described will be perhaps more easily followed by having these tables before the reader's eyes.

Between p_s and the exhaust pressure p_e similar interpolation formulas will be used. No doubt from the standpoint of strict logic it would be preferable to extend Table IV down to the Wilson line and start the new interpolation formulas at that point. There is, however, the difficulty that it is quite possible that there is no very definite relationship between the pressure and the volume, once precipitation of the moisture has commenced, until the expansion has been carried considerably beyond the supersaturation limit. In fact, where a change long overdue finally occurs, it not infrequently happens that repeat experiments fail to yield concordant results and events become regular again only at some distance from the region of transition. Under these circumstances, and whilst awaiting actual experimental figures it seems preferable to start the new interpolation formulas at the saturation line.

The method followed is exactly the same as before. We have $H_s = 647{\cdot}54$ and $H_e = 545{\cdot}79$, whilst $p_s V_s = 412{\cdot}20$ and $p_e V_e = 258{\cdot}27$, from which from the formula :

$$H_1 - C = \frac{p_1 V_1 (H_1 - H_2)}{p_1 V_1 - p_2 V_2}$$

we get $C = 375{\cdot}10$, and thus

$$\frac{H_s - C}{\eta} = 363{\cdot}2 \text{ and } \frac{H_e - C}{\eta} = 227{\cdot}6.$$

Taking one-tenth the differences of the logarithms of these numbers we subtract it ten times in succession from the initial value, and treating $\log p$ similarly we get the corresponding values of the two functions as tabulated, and, as already explained, corresponding values of $\log V_s$ are similarly obtained. These values are entered in Table V, and are determined more rapidly and accurately than they could be measured from a chart. As before, a check is provided by the fact that at the tenth operation we ought to get the known values of $\log \frac{H_e - C}{\eta}$; $\log p_s$ and of $\log V_s$.

TABLE V.

Point.	Log p.	Log $\frac{H - C}{\eta}$	$\frac{H - C}{\eta}$	U.	Log V.
L	1·4771	2·56010	362·5	0·0	1·1380
M	1·2985	2·53981	346·6	16·4	1·2963
N	1·1199	2·51952	330·8	32·4	1·4546
O	0·9413	2·49923	315·7	47·5	1·6129
P	0·7627	2·47894	301·2	62·0	1·7712
Q	0·5841	2·45865	287·5	75·7	1·9295
R	0·4055	2·43836	274·4	88·8	2·0878
S	0·2269	2·41807	261·9	101·3	2·2461
T	0·0483	2·39778	249·9	113·3	2·4044
U	$\bar{1}$·8697	2·37749	238·5	124·7	2·5627
V	$\bar{1}$·6911	2·35720	227·6	135·6	2·7210

* Page 297 of "Properties of Steam," by H. L. Callendar.

* Callendar's "Properties of Steam," page 314.

Tables IV and V, taken in conjunction, specify the thermodynamic head expended down to, and the pressure and the volume at, twenty points of the expansion. Of these points ten lie above the saturation line and ten below it. By plotting curves, or by the usual formulas of interpolation, intermediate values can be determined to any degree of precision required. It will be noted that K in Table IV, and L in Table V, refer to one and the same point of the expansion.

A slight digression here on certain very useful checks on the accuracy of logarithmic computations may perhaps be of service to some of our readers. Most people know the method of checking multiplications by "the casting out of nines," but it seems less generally realised that the same principle is applicable to the checking of additions and substractions, and is exceedingly convenient in logarithmic calculations, especially when four or five figure logarithms are employed. In that case the residue left on "casting out the nines" can be seen at a glance. Referring to Table IV, it will be seen that above each entry in the second column a single small figure has been printed. This figure, which for want of a better term the writer has been accustomed to call an index number, represents the residue left after "casting out the nines" from the number below it. In any addition, if the work is done correctly the sum of the index numbers (after, if necessary, casting out a nine) must be the index number of the result of the addition, and similarly with subtraction. Thus in Table IV the entry opposite point B is obtained by subtracting 0·08995 from the entry opposite A, and, as shown, the index number over the entry 2·28665 is the difference between the index number for 2·37660 and the index number for 0·08995, a check is thus provided at each successive subtraction. In carrying out the operation the number 0·08995 is written on the lower edge of a scrap of paper and brought over each successive figure in turn, as has already been explained above. In the original compilation of the table index numbers were written over most of the other entries, but these have not been reprinted. Many people find a difficulty in subtracting or adding two numbers placed side by side instead of one above the other. In such cases the use of index numbers will again be found of great assistance in securing accuracy. Of course, there is nothing new in the foregoing, but the method appears to be less popular than might have been anticipated. Its one defect, which, however, is but a slight drawback, is that the mistake of a nine will pass undetected. It may further be pointed out that logarithmic tables requiring the use of proportional parts are to be avoided unless the user is exceptionally expert in mental arithmetic. Probably the best four-figure table is that published by the Cambridge University Press. This has, amongst other good points, a "thumb index," which makes it possible to get at any particular entry almost instantaneously. Where greater accuracy is required, Chambers' seven-figure tables may be used as five-figure tables, with much less strain and risk of error than the usual five-figure tables with which interpolations are necessary. In taking out figures from a table the risk of error will be reduced if such a figure as say 13246 is read as thirteen, twenty-four, six, and not as one, three, two, four, six. There is a danger in the latter case of inverting the order of some of the figures.

(To be continued.)

AN ENGINEERING WORKS LABORATORY.

A works laboratory has now come to be considered as an indispensable part of the organisation of any large engineering firm. It provides a place where routine tests of material purchased or manufactured can be carried out under proper supervision, and also enables special research work to be undertaken with a view to the improvement of factory processes. These, indeed, are its obvious functions, but a well-organised works laboratory acts in addition as a central scientific department for the firm where information of certain kinds is collected, analysed and preserved for reference whenever problems arise which call for such knowledge. The existence of such a department tends to preserve all experimental knowledge once acquired, and its records not only assist in avoiding the repetition of mistakes, but eliminate the necessity for the verification of half-forgotten facts. These considerations more than justify the maintenance of a works laboratory by every firm which seeks to keep in the forefront of progress, and the country now contains very many excellent examples of the kind. Among these few, if any, are better equipped than the works laboratory of Messrs. W. H. Allen Sons and Co., Limited, of Bedford. This firm, of course, are well-known as manufacturers of a wide range of high-grade mechanical engineering products, including high-speed engines, turbines, oil engines, condensing plant, centrifugal pumps and fans and electrical machinery, so that the routine tests to be carried out in addition to the special researches required demand laboratory facilities and equipment of exceptional completeness.

Messrs. Allen's laboratory is housed in a separate building, specially built for the purpose, so that the various departments are all under one roof and free from the noise and distraction which contiguous workshops might cause. The complete building is 135 ft. long by 30 ft. wide., and is illuminated by a north-light roof from end to end in addition to numerous windows. The central portion constitutes the main mechanical testing room, which is 60 ft. long by 30 ft. wide. At one end of this room is the chemical laboratory with its balance room and stores, while at the other are the recalescence room, photo-micrographic room, dark room and office. A photograph of the interior of the mechanical testing room is reproduced in Fig. 1, above. In the foreground, in order from left to right, will be seen a Brinell hardness testing machine, a Sankey autographic bending testing machine, machines for repeated impact testing by the Eden-Foster and the Stanton type respectively, and an Izod single

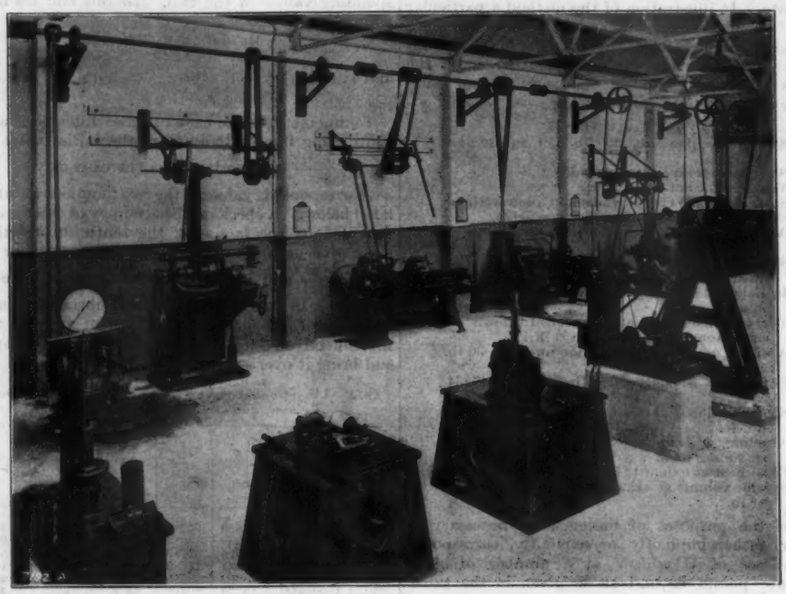


FIG. 1. MECHANICAL TESTING ROOM.

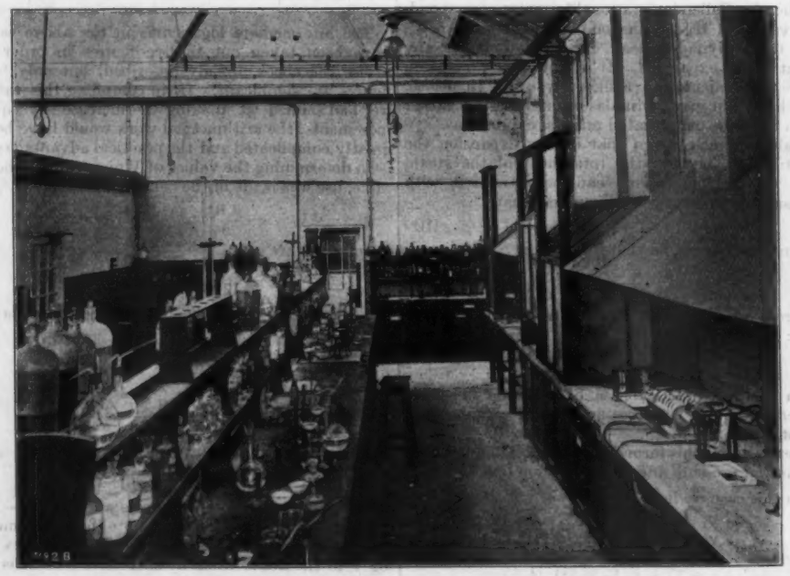


FIG. 2. CHEMICAL LABORATORY.

impact testing machine. In the same room, but not shown in the photograph, is a 30-ton Buckton tensile testing machine fitted with a Ewing extensometer, and a Shore hardness testing machine. Against one wall are a couple of gas-fired muffle furnaces, equipped with pyrometers and having quenching tanks adjacent. Along the other wall are lathes and milling and grinding machines for the preparation of test specimens of any form, or for any other machining that may be required.

FIG. 3. BALANCE ROOM.

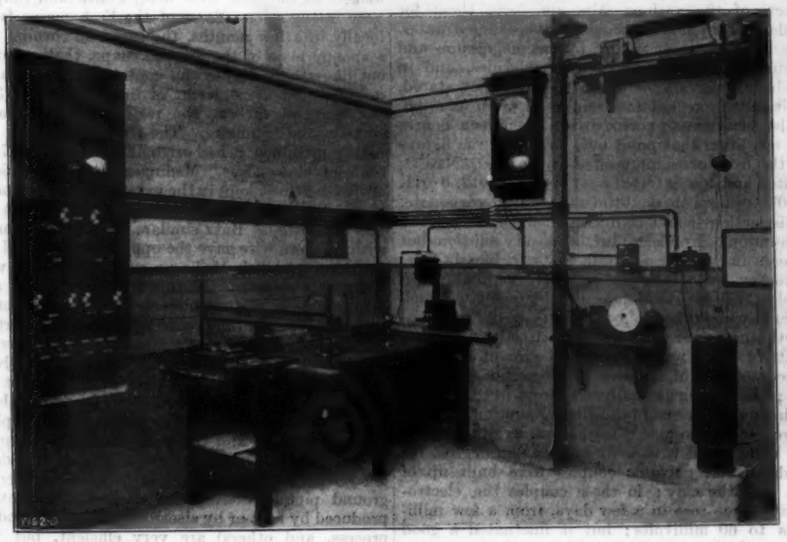


FIG. 4. RECALESCENCE ROOM.

It will be seen that the equipment of this room provides for practically every test that has been devised for ascertaining the mechanical qualities of metals, while the well-lit and spacious interior enables the work to be carried out with accuracy and comfort.

The chemical laboratory, part of which is shown in Fig. 2, is 40 ft. long by 20 ft. wide. It is fitted with all the appliances and apparatus necessary for the analysis of the materials used in engineering construction, and separate benches are devoted to the examination of fuels, lubricating oils and waters. The accurate weighings involved in the work are carried out in a separate balance room, a view of which is given in Fig. 3. The recalescence room, shown in Fig. 4, contains apparatus for taking the heating and cooling curves of metals and alloys. For such work it is, of course, essential that the specimens should be heated and cooled with extreme regularity, and this is ensured by the type of furnace used. This takes the form of a tube, electrically heated at the top, and so arranged that there is an even temperature gradient from top to bottom. The specimen is very slowly raised or lowered in the interior of the tube by means of winding gear driven by an electric motor geared down in the ratio of 20,000 to 1. The furnace in question is a modification of one in use in the National Physical Laboratory, and described by Dr. Rosenhain before the Institute of Metals in 1915.

The duty of the observer is to record the time intervals taken by the specimen to pass through equal ranges of temperature. This he does by depressing a key at the proper instants, the key actuating a pen which marks the tape of a motor-driven chronograph. Another pen actuated by an electric clock records definite time intervals on the tape. At the critical points of steels and other alloys the specimen takes a longer time to pass upwards or downwards through the temperature range, and by plotting time intervals against differences on temperature the critical points are made evident. The temperature of the specimen is measured electrically. The E.M.F. indicating the temperature is measured partly by means of a potentiometer, the out-of-balance E.M.F. being shown by the deflection of a spot of light from a Campbell bifilar galvanometer along a scale previously calibrated in millivolts and degrees Centrigrade. By this method a very open reading is obtained, 100 cm. along the scale corresponding to only 2 millivolts. This recalescence apparatus was originally fitted in the old laboratory of the firm, and afforded invaluable information as to the correct heat treatment of a great number of different steels used in aero engine manufacture during the war. The photo-micrographic apparatus, housed in an adjacent room, consists of a Zeiss optical bench on which is mounted a Watson "Works model" microscope fitted with various Zeiss and Watson objectives. This enables permanent photographic records of the micro-structure of any metal to be obtained, and furnishes an indispensable aid to research into phenomena which depend upon the microstructure.

It is not possible to describe, except in general terms, the effect of such a laboratory as that of Messrs. Allen, upon the quality and uniformity of the products of the firm, but it is obvious that testing and research facilities of such completeness can only have a most favourable reaction upon manufacturing processes. The control exercised by the laboratory, or to put it more accurately, the control rendered possible by the work of the laboratory is very complete. The castings produced by Messrs. Allen vary widely in their purposes and, therefore, in the characteristics which are desirable. In order to ensure the maintenance of the respective qualities, daily tests of the mechanical properties of all the different mixtures are carried out, and at least twice weekly, samples from all the mixtures are subjected to chemical analysis. Should these analyses show any marked deviation from the normal, daily analyses are made until uniformity and consistence with the desired composition have again been restored. The mechanical tests for cast iron are both transverse and tensile. In the former the loads required to fracture either a 2-in. by 1-in. bar supported at 3-ft. span, or a 1-in. square bar supported at 1-ft. span are recorded. Tensile tests are carried out on specimens 0·798 in. diameter by 3-in. acting length.

Mild steel is not bought on analysis, but on guaranteed tensile tests. Of the four qualities principally used, steel with an ultimate tensile strength of 28—32 tons per square inch is employed for cranks to Admiralty requirements, a 31—35 ton steel for other general forgings, a 34—38 ton steel for turbine rotors and gear wheel shafts, and a 40—45 ton steel for turbine pinion shafts. Case-hardening steel is bought as such, but its suitability is checked, both by tensile tests and by determination of the carbon contents. A true case-hardening steel should not contain more than 0·15 or 0·16 per cent. of carbon, and should have a tensile strength not exceeding 25 tons per square inch. Steel with a carbon content of 0·18 per cent. to 0·23 per cent., and a tensile strength of 31—35 tons can be used for case-hardening if quenched in oil instead of water, and even higher carbon contents can be used if oil-hardened and tempered. But much steel is supplied as case-hardening steel which is quite unsuitable for the purpose, and the laboratory is valuable in enabling this to be detected before time and money has been spent in trying to use it. The suitability of the four classes of steel mentioned above, for their respective duties is not presumed merely from the fact that they fulfil the conditions of the tensile test. In addition to this test, the Stanton, Izod, Sankey, and Eden-Foster tests are applied as a matter of routine. The exact interpretation of these tests is recognised by all engineers as a matter of considerable difficulty, but by correlating the results of the tests with the behaviour of the material in actual service, extremely useful information is acquired, and it will doubtless be possible in time to predict with some certainty the durability of any class of material under given conditions.

The importance of tests other than tensile for determining the suitability of metal for certain

purposes is well shown by the research carried out at Bedford on eyebolts. The results of this investigation were put before the Institution of Mechanical Engineers by Mr. R. T. Rolfe, F.I.C., by permission of Messrs. W. H. Allen, Sons and Co., Limited, of the work of whose laboratories Mr. Rolfe is in charge, and published in the Proceedings of the Institution for last February, under the title of "The Mechanical Qualities Required in Eyebolts." Until the occurrence of numerous failures in the first batches of several sizes of eyebolts supplied by outside stampers, it was assumed that so long as the steel was of 31—35 ton tensile strength, everything would be satisfactory. In consequence of the failures the whole of the material was rejected, and Messrs. Allen decided to replace it by stampings of their own manufacture. To avoid a repetition of the trouble it was necessary to find out why the purchased stampings had failed, and to establish methods of controlling the quality of their own output. Investigation showed that the tensile test was quite useless, as it did not discriminate between good material and material which was hopelessly bad for the purpose in view. The Izod test, however, was found to detect unsuitable material with certainty. No eyebolts are manufactured by Messrs. Allen without test pieces being put through with each batch under exactly the same conditions as regards manufacture and heat treatment as the stampings. The stores order-card relating to the batch is sent with the test pieces to the laboratory, and the batch is not released to the stores until the card in question has been returned to the stamping department, duly endorsed, as a certificate that the batch has been tested and passed. If a batch were received in the stores without this certificate of test, it would be returned to the stamping department. The test on which the batch is passed is a minimum of 20 ft.-lbs. on the Izod machine.

We could give many more instances to show the nature of the control exercised by the laboratory over the quality of the firm's manufactures, but this is unnecessary, as the very existence of so well-appointed a laboratory presupposes its effective utilisation. Research work of one kind or another is always in progress, and though to paraphrase the words of Shakespeare, 'tis not in laboratories to command success, success will eventually be achieved by the firms who deserve it. One looks more hopefully to works' laboratories founded and maintained by private enterprise than to State-aided institutions of the academic type, for the solution of those practical manufacturing problems, upon which our industrial progress so largely depends. Hence, it is a good sign that our leading engineering works are recognising the need for scientific research and are emphasising their recognition in a practical manner by maintaining laboratories where scientific investigations can be carried out under the most favourable conditions.

HYDROMETALLURGY OF LOW-GRADE ZINC ORES IN JAPAN.—Japan mines about 35,000 tons of zinc ore per year, but the conditions are not favourable for large-scale smelting because the ore deposits are widely spread. The figure mentioned does not comprise the low-grade ores, so far hardly utilised, on the hydrometallurgy of which Motohiro Namra publishes a paper in the Journal of the Society of Chemical Industry, December 15. He has, since 1910, been experimenting with ores of the following percentages: Zinc, 32 to 35; copper, 2; lead, 7; sulphur, 22 to 25; barium, 3; silver, 0·0323; and his wet extraction process has been adopted at the Takachiho-Seirensho Works.

QUEENSLAND'S OIL RESOURCES.—Mr. Theodore, Prime Minister of Queensland, recently interviewed the Commonwealth Premier, Mr. Hughes, at Melbourne, with reference to the development of the Queensland mineral oil industry. He proposed that the Federal Government should co-operate with the State Government in further developing the oil bore at Roma, which is already giving encouraging results. Mr. Hughes suggested an arrangement similar to that of the Commonwealth Oil Refineries, in which the Federal authorities have two-thirds of the shares and the Anglo-Persian Oil Company one-third. This proposal is now under consideration, and meanwhile the State Government is continuing its investigations at Roma and elsewhere in Queensland. The correlation of the strata in the Roma oil bore with belts outcropping on the surface north of Roma has been satisfactorily achieved, and an average dip of 100 ft. in the mile has been found to hold in the country north of that town. Five years ago the Government installed some oil-boring plant, and since then many thousands of pounds have been spent in boring and casing, with results that have at length proved satisfactory.

CORROSION OF CAST-IRON IN ALKALINE SOILS.

THE soils of the Winnipeg districts and of other parts of the north-western prairies of Canada are rich in lime and "alkaline salts," sufficiently sometimes to impede plant growth in the surface layers. That these soluble minerals disintegrate the Portland cement-concrete of foundations and sewers, &c., had long been recognised before the conviction gained ground that the salts were largely responsible also for the destruction of iron pipes, which had too readily been ascribed to the action of stray electric currents. Pipe lines and electric lines have necessarily to co-exist, though they are kept as far apart as possible. But bad corrosion of iron pipes was frequently observed at spots miles away from any electric tracks. When the Engineering Institute of Canada discussed these problems at Saskatoon last August, Mr. W. Nelson Smith, consulting electrical engineer to the Winnipeg Electric Railway, and Dr. J. W. Shipley, of the University of Manitoba, in a paper on "Self-Corrosion of Cast-Iron and other Metals in Alkaline Soils," charged the salts with the responsibility for the corrosion. There is no doubt that iron will corrode independent of stray currents, but hardly independent of local electrolysis, and the recognition of that fact, though not novel, is of importance to the engineer.

Messrs. Smith and Shipley found that calcium and magnesium sulphates, as well as their chlorides, carbonates and bicarbonates, predominate in the 10 ft. or 12 ft. of surface layer which are cut through when pipes are laid in Winnipeg. The salt distribution is irregular. Lumps of solid salts occur in veins and in the cavities, once filled by roots of trees. They regard these deposits as the reservoirs from which the ground waters receive their saline charge; we rather consider the deposit to be due to the infiltration into the cavities of gradually concentrating solutions. Smith and Shipley conducted various corrosion tests. They placed pieces of new cast-iron pipes into solutions, in distilled water, of the various salts and kept them for 40 days at 90 deg. C., renewing the distilled water. The iron lost most weight in the magnesium and calcium sulphates, also in the chlorides, and in the bicarbonates. Sodium carbonate, they stated, positively protected the iron, as is often asserted, whilst bicarbonate corroded it; their own figures did not bring that point out, however—the figures for the iron losses in grammes in $NaHCO_3$, Na_2CO_3 diluted and concentrated are: 0·014, 0·012, 0·011, 0·007—and we are doubtful as to sodium carbonate. A distinction should be drawn between rusting and dissolution. Iron keeps bright in soda solution, but it loses in weight, whilst it rusts in bicarbonate. Moreover, since the solutions were kept hot, and would therefore decompose the bicarbonate, much difference could hardly be expected.

Other tests were made in gravity cells, in which a diluted solution was floating on the top of a concentrated solution of the same (or sometimes another) salt; the rusting generally was worst in the portion of the iron immersed in the diluted solution. Pieces of iron were also placed in the soil, to which water was added, and were kept again at 90 deg. C. for 40 days, and galvanic couples were built up of iron and the clay; in these couples the electromotive force rose in a few days, from a few millivolts to 60 millivolts; but it fluctuated a good deal, and the polarity would sometimes reverse. Ammonium salts, especially the nitrate, which are very bad corroders, were not tested. The electric resistance of the wet clay was found to be about 570 ohms (200 to 1,100) per cubic metre, whilst a coarse gravel backfilling gave 12,000 ohms. The soil resistance was generally higher near gas pipes than near water pipes; the ground is drier, probably on account of the higher temperature of the gas, in the former case, and the gas pipes corrode less. The corroded pipes were generally found to be dark bluish green, turning reddish on exposure to air. The iron was mostly pitted, the pits being filled with a soft mass rich in metallic iron and graphite. Occasionally soft, small lumps rich in phosphorus were observed.

The tests and observations are interesting. But the salt concentrations are not specified; most investigators consider certain concentrations as critical, and it would at present require very extensive researches to bring out novel points. Smith and Shipley insist that the corrosion of iron does not require the presence of both water and oxygen, though that is often asserted. Iron, they say, has a higher solution pressure than hydrogen, and it will pass into solution if it can displace hydrogen ions. It can do so in pure water because it is, to a very slight degree, dissociated into ions of hydrogen and hydroxyl; the presence of electrolytes is favourable to corrosion if they supply hydrogen ions (salts), but not if they supply hydroxyl ions (caustic alkali). That we may accept with reservations. The phenomena are complex. Chemical and electrolytic processes go together. Neither the iron, nor the soil in which it lies are uniform. In the presence of electrolytes potential differences and local currents are set up, if only by the graphite and the impurities in the iron. If the conditions tend to an equilibrium, the corrosion will soon come to a stop. That is so in pure water, because it contains very few free ions. In the presence of electrolytes it may also occur with an ample supply of oxygen which depolarises the hydrogen liberated and which produces an insoluble ferric oxide protecting the iron. When little ogygen is supplied, the oxidation stops at the ferrous, unprotective state, and the corrosion continues; all acids attack iron under these conditions, the rain brings carbon dioxide, sulphur dioxide, nitrous acid, &c., down into the soil, and many salts help the humic acids and other acids there. Thus oxygen may both promote and prevent corrosion; it depends upon local conditions, not really understood. Pipes laid in gravel will mostly be dry; in clay they will be more or less damp all the year round.

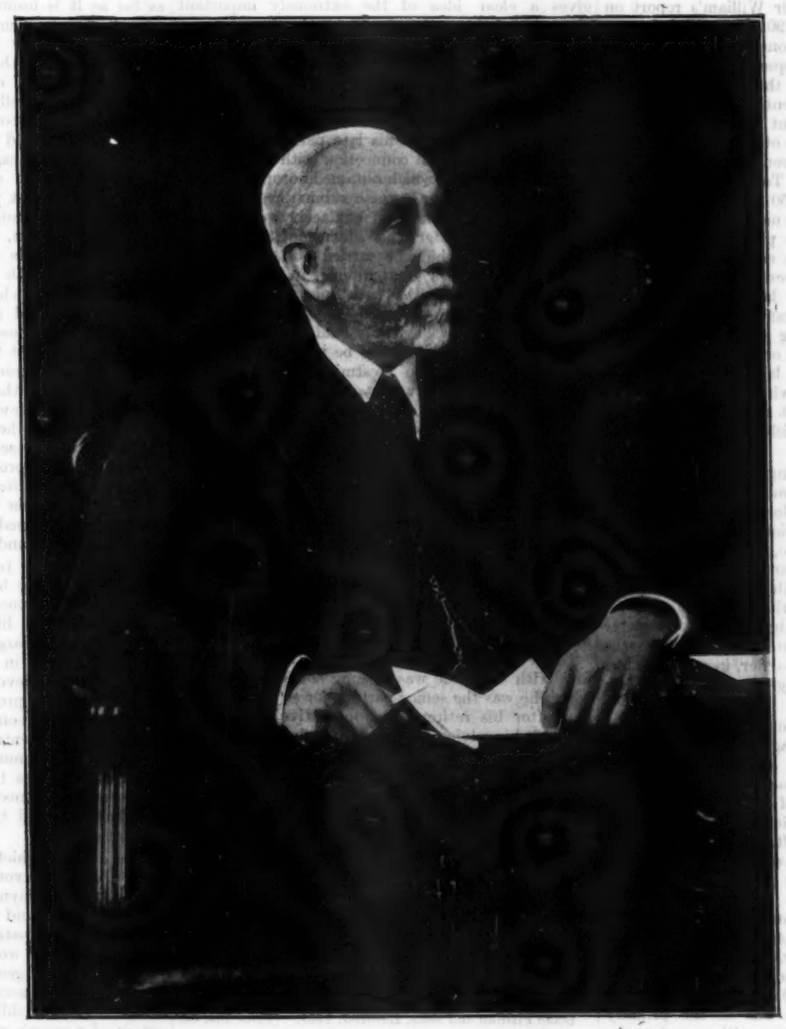
That calcium sulphate and bicarbonate in heavy clay are particularly dangerous to iron pipes was observed by P. Medinger, at Esch in Luxemburg, to whose paper in the "Journal für Gas und Wasser" (1918, pages 73 to 76 and 89 to 91, overlooked at the time over here) Smith and Shipley very briefly refer. Some of the Esch mains failed locally in a few months, the cast-iron turning into a spongy mass of the original shape, that could be cut like a hard cheese and contained 41·5 (against originally 92·6) per cent. of iron, and 14·7 (3·4) per cent. of carbon, the rest being phosphates, silicates and sulphates. The transformed iron was mostly metallic; it had originally contained 1·7 per cent. of phosphorus. Medinger found that pieces of this cast-iron, kept in the wet clay under exclusion of air lost twice as much in weight as when air was admitted. But similar experiments made with fine iron wire gave the opposite result, and the dissociation which Medinger suggests is of a very complex character. Fortunately progress is also being made in the methods applied for preventing corrosion, though the processes in use might further be improved. Medinger's pipes had been tarred; but it was not well done, and should have been renewed on the flanges which suffered most by corrosion because they had been knocked about more than other parts. The tar should be applied to the hot pipes, and the pipes finally be wrapped with jute. Baking the pipes in oil has also done good service. Painting is little good for underground pipes. Coatings of magnetic iron oxide produced by heat or by electrolysis (Sestini-Rondelli process, and others) are very efficient, but too expensive for ordinary purposes.

AMERICAN PATENT OFFICE DELAYS.—Protesting against the delays on the part of the Patent Office in granting patents, 75 patent attorneys of New York, says *The Iron Age*, met at the commencement of the present month and passed resolutions calling on Congress for a remedy. It was stated that over 57,000 inventions were now lying in the Patent Office awaiting examination. Inventors were compelled to wait years before they could obtain capital to finance their inventions, due to the unwillingness of business men to put money into an invention unprotected by a patent. During the present period of unemployment and depression, Congress should do everything in its power to encourage the development of new industries. Congressman Bond, New York, assured the meeting that he would work for the passage of a Bill now before the House of Representatives which would increase the number of the salaries of the technical staff of the Patent Office. A committee was appointed to work for the desired improvements.

THE LATE SIR WILLIAM MATTHEWS, K.C.M.G.

By the death of Sir William Matthews, K.C.M.G., a past president of the Institution of Civil Engineers, there has been removed from the roll of distinguished Imperialists one who did great service towards building up and consolidating the Empire. It has been demonstrated by the ordeal of battle that Britain and the dominions and colonies beyond the sea are not mere geographical entities, but are bound together by the ties of a common origin and common sympathies, which latter are further maintained by frequent and intimate intercourse. The medium of such connection are the ships which traverse the seas, but to these terminal harbours and coaling stations *en route* are indispensable essentials. Sir William Matthews for nearly 50 years devoted his professional ability and experience, along with an enthusiasm for Imperial advancement, towards the building and maintenance of such harbours, serving as consultant to various Government departments and harbour authorities as well as to private clients, and carrying out extensive works under personal direction. At home he was concerned to a more or less extent with commercial harbours on the Mersey, Tyne and Humber, and at Folkestone, and with naval harbours at Peterhead, Dover and Keyham, while on the routes to our great dominions he did great work at Malta, Colombo, Singapore, Cape Town and other ports.

Sir William was born in Penzance in 1844. His father was surveyor of that borough and was also engaged in constructive works generally in west Cornwall. At the age of 16 he entered the engineering works of Messrs. Sandys, Vivian & Co., of Copperhouse, near Hayle, in Cornwall, a firm which at that time was well known as makers of heavy pumping and mining machinery. He remained there about 12 months, when, work becoming slack, he returned to his father's office at Penzance and was engaged there in surveying and constructive works until 1864. In the last-named year the corporation of Penzance consulted Mr. (afterwards Sir John) Coode with regard to the construction of a wet dock in the tidal harbour of that port. In connection with this investigation it became necessary to make a somewhat extensive engineering survey of the harbour of Penzance and the foreshore and sea bed in the vicinity thereof. The subject of this memoir was entrusted with this work, and this proved the turning-point in his life, as soon after the completion of the investigation he received a permanent appointment on the staff of Sir John Coode, first by arrangement as his pupil, and for 22 years from this date he continued as his chief assistant, while subsequently, in 1892, he and Mr. J. C. Coode (Sir John Coode's son) became partners in the firm.



THE LATE SIR WILLIAM MATTHEWS, K.C.M.G.

The firm of Sir John Coode, and subsequently of Coode, Son, and Matthews, was well known in connection with harbour, dock, river and estuary works at home and in the colonies. During the frequent absence of Sir John Coode on his colonial tours, which on one occasion extended over a period of 10 months, the home business was managed by Mr. Matthews, his chief assistant, and this afforded him unusual opportunities of obtaining large and varied experience in the exercise of his profession. From his admission into the firm in 1892 the subject of our memoir led an extremely busy life, visiting home and colonial ports, preparing designs and estimates for various harbour, river and dock undertakings, and inspecting and directing works in progress. These duties took him to Ceylon, Hong Kong, Singapore, Penang, the Malay States, the Cape, Cyprus, Gibraltar, Malta and other ports where professional work was being done under the firm's direction, as well as at home.

The firm of which Sir William was a member has for many years occupied the position of consulting engineers for harbours and docks to the Crown agents for the Colonies. In fact Sir William was the senior consulting engineer to that department, in order of date, having been connected with it, as advising on professional matters, for nearly 40 years. The firm was also employed by the Admiralty from time to time in connection with works at naval bases, and in that capacity reported on the dockyard extension works at Keyham, Devonport, and advised on the general arrangement of those works, also as to the sheltering breakwaters at Malta, which were required for the protection of the Grand Harbour during "grigales" or strong north-east winds. This work was carried out by the Director of Works Department. The principal work, however, with which the firm was connected for the Admiralty was the naval harbour at Dover, commenced in 1896 and completed in 1909, by which an area of 610 acres was enclosed for naval purposes and 80 acres as a commercial harbour.* This great

* See ENGINEERING, vol. lxxx, page 501.

undertaking was successfully carried out under the Naval Works Act, Sir Henry Pilkington at first, and Sir Edward Raban subsequently, being engineers-in-chief, and Messrs. Coode, Son, and Matthews, chief engineers, the contractors being Messrs. S. Pearson and Son. The sheltering piers of the enclosure are of great extent, the prolongation of the original Admiralty Pier being 2,000 ft. in length and nearly 100 ft. in height from foundation to parapet, of which height 60 ft. was below low water.

The firm also advised the Board of Trade and sometimes the India Office, and occupied the position of consulting engineers to the Mersey Conservancy, the Humber Conservancy, the Tyne Commissioners, and other public bodies. Sir William's report on the Humber, prepared in 1905, is regarded as a record among river reports, containing data of great value for reference on all questions which affect that river. In addition to those already referred to, the following may be mentioned as among the principal and most important works carried out: The harbour of Colombo, one of the largest artificial harbours which has yet been constructed; the harbour and docks at Cape Town, commenced by Sir John Coode upwards of 50 years ago and since extended from time to time to meet trade expansion; the rebuilding of the north pier at the entrance to the Tyne, carried out in conjunction with Sir John Wolfe-Barry as engineers; the new pier at Folkestone, which was so largely used during the war for cross-Channel traffic; the Harbour of Refuge at Peterhead, having a low-water area of 285 acres, now being carried out for the Admiralty, and where Scotch convict labour is extensively employed. In connection with these last-named works it is well known that they are exposed to exceptionally heavy seas which make the work of special difficulty.

An extensive and interesting work completed by the firm in 1904 is the sea embankment, or barrier, in the estuary of the Duddon at Hodbafrow, in Cumberland, the object of which was to shut out the sea from 170 acres of foreshore, in order to enable an exceptionally rich and abundant deposit of hematite iron ore, which lies at a depth of 300 ft. below the sea bed, to be won. The work, which was of novel construction, had to be watertight and of a character to resist wave action during storms from the south-west, and the closing of the barrier, in order to shut out the tide, was an interesting but at the same time an anxious proceeding.

One of the most important series of works on which Sir William was engaged during the later years of his life were those at Singapore. These consist of a wet dock of 24½ acres in area, having a depth of 30 ft. at low water of ordinary spring tides, and a graving dock 846 ft. in length on the floor, having an entrance of 100 ft. in width at coping level and a depth over the sill of 34 ft. at high water ordinary spring tides, being probably the largest dock of its kind in the East. In addition to these works there was the reconstruction of the main wharf, having a length of 4,400 ft., with 33 ft. of water alongside at low water. In connection with the works above referred to Sir William visited Singapore at the end of 1901 and again in 1905. On the last-named occasion one of the primary objects of the visit was to advise with regard to the taking over by the Straits Government of the well-known works and property of the Tanjong Pagar Dock Company and to give evidence in an arbitration held in Singapore on this important subject.

Sir William in the later years of his life was a member of several Commissions and Committees, such as the Royal Commission on Coast Erosion in 1906, the International Technical Commission on the Suez Canal in 1908, the Royal Commission on Oil Fuel and Engines in 1912. He was president of the Institution of Civil Engineers 1907–8, and chairman of the British Standards Cement Committee from its inception onwards, and also chairman of the Committee on Reinforced Concrete established by the Institution of Civil Engineers in 1908.

No account of Sir William Matthews' career would be complete without special reference to the important work done by him in connection with the committee, appointed by the Institution of Civil Engineers, to investigate the Deterioration of Structures of Timber, Metal and Concrete exposed to the action of sea water. This committee, which was established as the result of an inquiry inaugurated by the Institution in 1916, and of which Sir William Matthews was the chairman until last year, may justly be regarded as having in hand the most important field of research ever undertaken by a scientific institution, and its successful organisation has been very largely due to the zeal and persistence of the subject of our memoir. It is not possible to deal here with the scope of this research, but we may refer our readers to a review, published in our issue of April 30, 1920, page 584, of the first report made by this committee, which gives a clear idea of the extremely important character of the work it has in hand.

Sir William obtained the honour of C.M.G. in 1901 "for services in connection with colonial harbours," and was promoted in the Order to a Knight Commandership in 1906. He was also an Officer of the Order of Leopold, which was conferred upon him, as also upon his late partner (Mr. J. C. Coode), for services in connection with the harbour of Zebrugge, a port which obtained notoriety during the war as a base for German submarines.

A very large number of engineers were trained by and worked under Sir William Matthews on the different works which he carried out. He always continued to take a great interest in the career of those who had been his assistants, and it always gave him great pleasure when they came to see him in London. Sir William was kind and generous to his staff, and his death will be regretted not only by many engineers in Westminster, but by large numbers scattered in various parts of the world.

About the year 1917 the great vitality which had been a characteristic of his whole life had, under medical advice, to be kept in subjection, but although he retired from partnership in his firm towards the end of that year, he continued to give consultative advice to the remaining partners. It was only towards the end of 1920 that he ceased to attend daily at the office.

The firm was reconstructed in 1912, and again in 1921, and now includes Sir Maurice Fitzmaurice, C.M.G., F.R.S., Mr. M. F. G. Wilson, Mr. A. T. Coode (Sir John Coode's grandson), Mr. H. H. G. Mitchell and Mr. A. G. Vaughan-Lee.

Sir William never lost interest in the work of the firm with which he was so long connected, and of which he was the senior partner for so many years, and after his retirement from active partnership in 1917, his advice was of great value to the firm.

He was able to get about up to September of last year, but after that time his health began to fail rapidly, and the end came on the evening of Sunday last, the 8th inst., at his residence, 14 Strathray Gardens, Hampstead.

LITERATURE.

British Labour, Replacement and Conciliation, 1914–21, being the Result of Conferences and Investigations by Committees of Section F of the British Association. Part I. *On Replacement.* By Miss L. GRIER and Miss A. ASHLEY, M.A. Part II. *On Conciliation.* Edited by A. W. KIRKALDY, M.A. London: Sir Isaac Pitman and Sons, Limited, 1921. [Price 10s. 6d. net.]

WHEN the Great War threatened Europe, the members of the British Association were on their way to Australia with a detailed programme that completely engaged their activities, and it was not till the meeting of 1915 that the mechanism of the Economic Section could be put into operation, and the accumulated experience of the members be directed to assisting the country in the crisis through which it was passing. Then no time was lost, and several committees were appointed to investigate certain phases of the problem, arising from the disturbance of the ordinary channels of industry and commerce. The carefully-weighed opinions of recognised authorities necessarily carried great weight, and the successive reports issued from time to time by the British Association were eagerly sought by the public and are now out of print.

It has been thought desirable to give the reports just mentioned a permanent form, and the volume now under notice sums up and co-ordinates the views of the section relating to labour. That the Economic Section should wish to demonstrate that they had recognised and fulfilled their proper function is easy to understand, but it is difficult to estimate the value of the book as a contribution to the practical solution of the grave problem that confronts the nation at large. As one of the contributors points out, it is not the function of the economist to design plans for the smoother working of the industrial machine. He can point out imperfections and make suggestions, but only those conversant with the practical working of the complicated organisation can formulate a practical policy.

Possibly discussion has already been carried as far as it is useful: those who are willing to be convinced have ample facts for their guidance, and the unwilling give no heed to information however trustworthy or irrefutable. We weary of the repetition of the obvious, the soothing conjectures of well-meaning optimists, and the lamentations of confirmed pessimists. Probably all those who would read this volume are convinced of the need of measures for promoting industrial harmony between employers and operatives, of getting the utmost possible production out of our industrial equipment, and of the necessity of greater individual exertion. But we fail to see how these and other objects considered are promoted by repeating at length the proceedings of a meeting, held in 1915, in which representative men in the respective field of capital and labour vigorously expressed their views and declared their position. It might be unjust to say that the futility of discussion and the presentation of reasoned statements are illustrated by the results of these deliberations, though there are few that will not admit that with the lapse of time, the perils and dangers threatening the country have sensibly increased, industrial unrest has become more prominent, trade has dwindled, the amenities of life are certainly diminished, and those least capable of guiding labour into happier paths have obtained enlarged power and mastery over inarticulate and servile workers.

If it is hoped to spread accurate information among the masses by furnishing broad and exact views of the economic position, this well-intentioned object is likely to be defeated by the action of that large and increasing class, who find their reward in fishing in the troubled waters of anarchy and revolution. Add to the effect of this mischievous propaganda, the efforts of those who are honestly convinced that the road to prosperity and contentment is to be found in the doctrines of Communism and the practice of Bolshevists, and it is to be feared that very drastic measures will be necessary to remove the obstacles that bar the road to healthier modes of thinking and action.

The section which gives us the greatest satisfaction is that devoted to the consideration of the temporary employment of women in industry during the war, and their subsequent reabsorbment into pre-war occupations. Though speculation on the future position of women is sometimes encouraged, the treatment is generally historical and the facts appear to be accurately collected, judiciously discussed and lucidly presented. The scope and extent of women's work in various trades, in agriculture, in transport service, in teaching, are carefully examined and the experience gained is thoroughly sifted. The value of women labour in the time of stress has never been seriously questioned, but its extent has hardly been appreciated. It may come as a surprise to many to learn that in the chemical and metal trades, it was not uncommon to find factories in which 95 per cent. of the employees were females.

The total number of women employed is difficult to estimate, but the figures given here point to the addition of 797,000 women to industrial and 871,000 to non-industrial occupations. Women entered into industry with a dramatic swiftness, only equalled by the speed with which they left it, say the authors, and indeed the exodus of women from their work has been effected with a silence and completeness that is astonishing. How they disappeared is not known, but it is satisfactory to read that remarkable little suffering was caused by the withdrawal by so large a body of workers.

1,500-VOLT DIRECT-CURRENT ELECTRIC FREIGHT LOCOMOTIVE

CONSTRUCTED FROM THE DESIGNS OF SIR VINCENT L. RAVE

(For Descriptio, see Pa

Fig. 4.

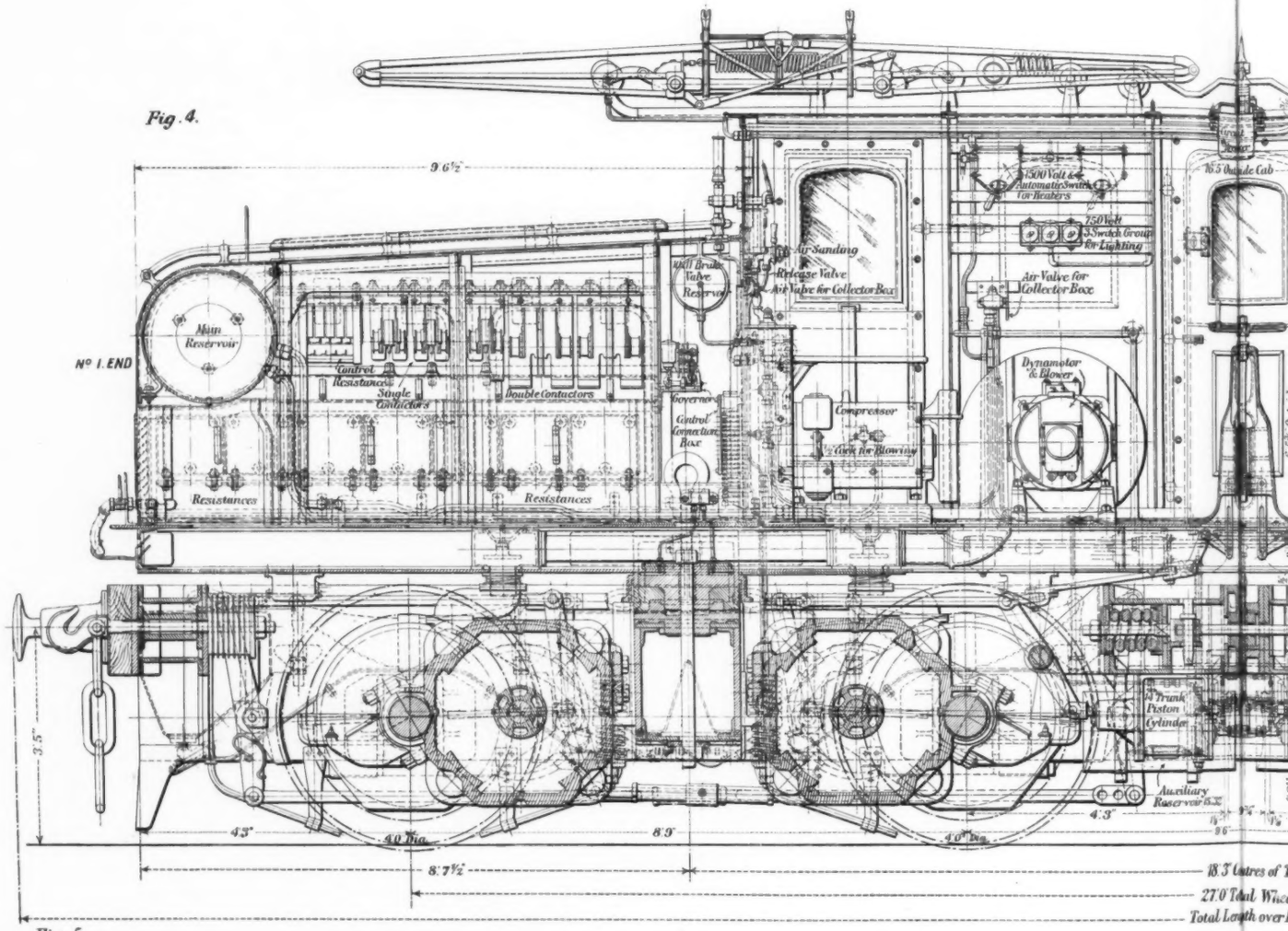
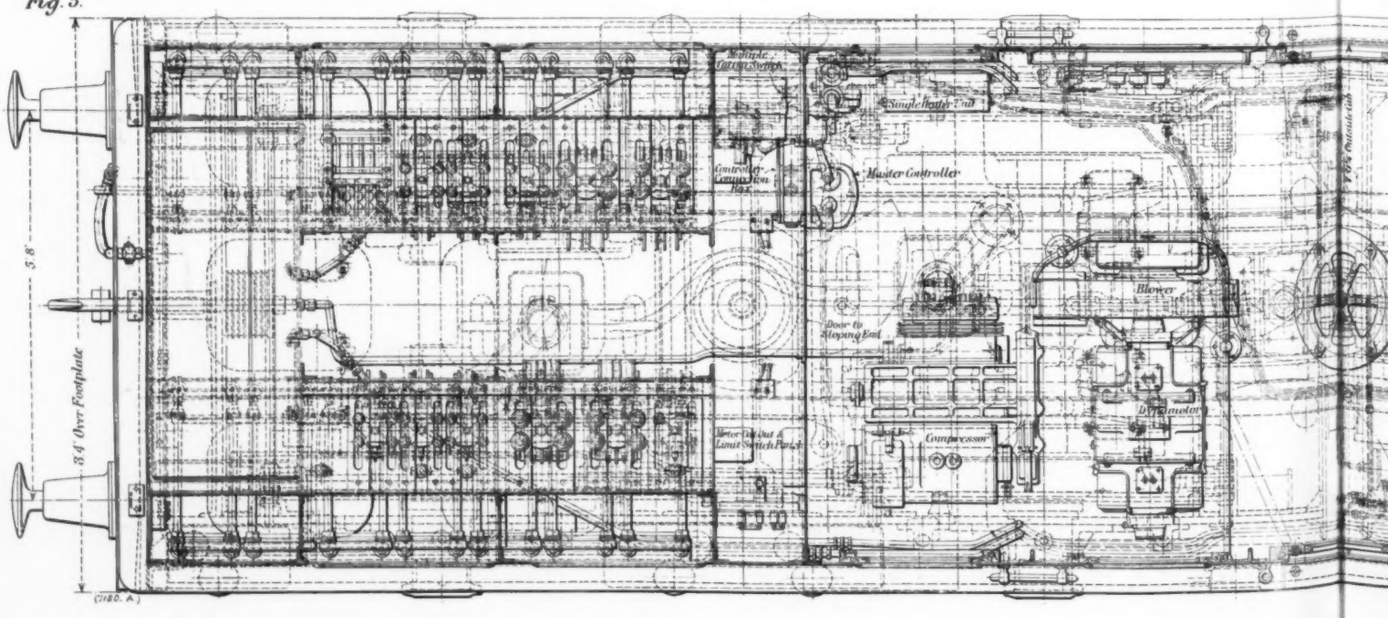


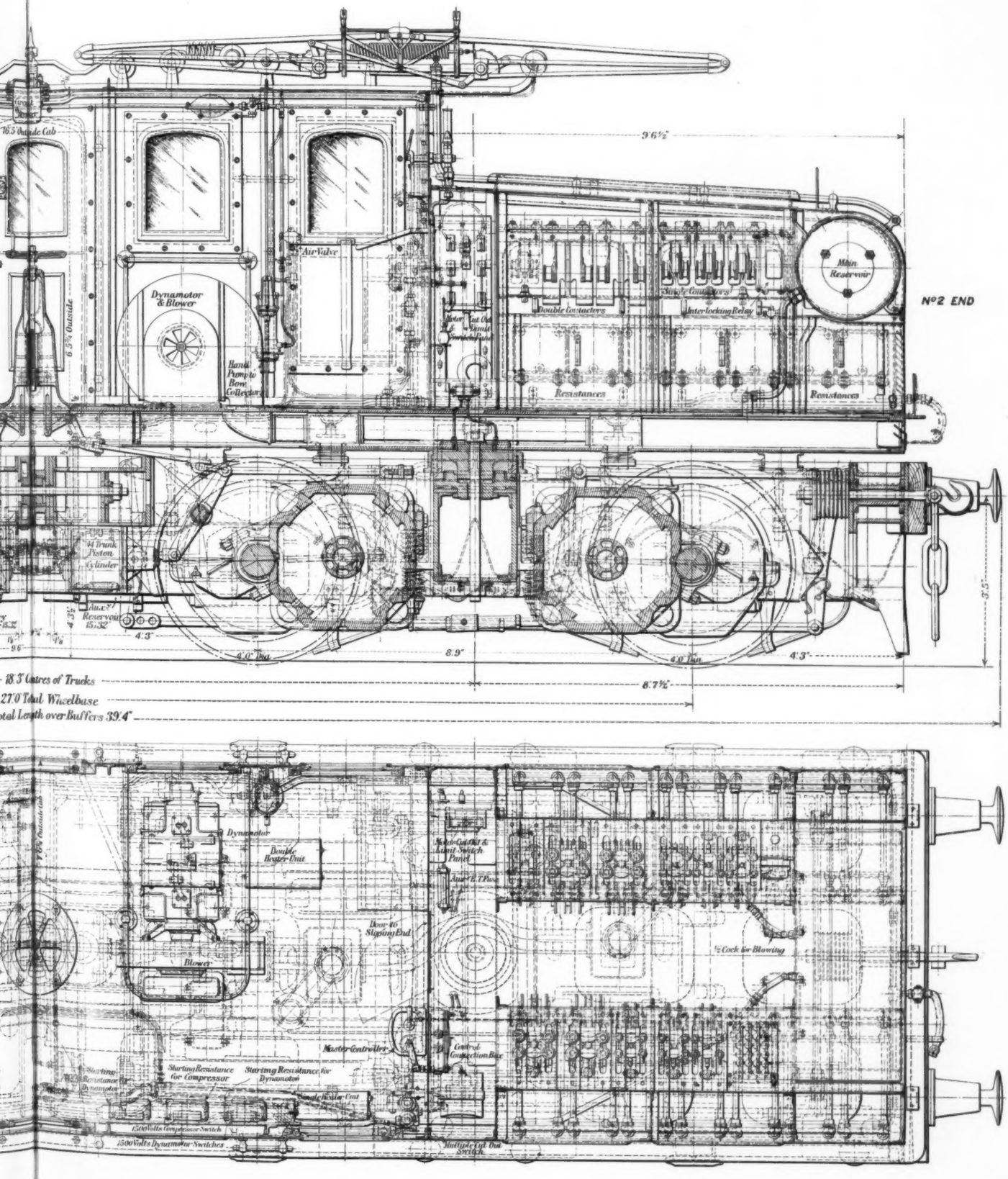
Fig. 5.



MOTIVE (0-4 + 4-0 TYPE) FOR THE NORTH-EASTERN RAILWAY.

NT L. RAVEN, M. INST. C.E., CHIEF MECHANICAL ENGINEER.

cription, see Page 39.)



RAILWAY ELECTRIFICATION.*

By Sir VINCENT L. RAVEN, K.B.E., M.Inst.C.E., M.I.Mech.E.

(*Concluded from page 26*).

RESULTING from the experience which has been obtained of electric locomotive operation in America, it can be definitely stated that electric locomotives show a considerable advantage over steam engines in the cost of repairs and maintenance. In a paper read before a joint meeting of the American Society of Mechanical Engineers and American Institute of Electrical Engineers at New York, on October 22, 1920, Mr. Armstrong, chairman of the Electrification Committee of the General Electric Company, gave the following table of electric locomotive maintenance for the year 1919:—

Electric Locomotive Maintenance Data for 1919.

——	New York Central Railroad.	Chicago, Milwaukee and St. Paul Railway.	Butte Anaconda and Pacific Railroad.
Number of locomotives owned	73	45	28
Locomotive weight, tons	118	290	84
Annual mileage	1,946,879	2,321,148	566,977
Cost of repairs per mile, cents	6·39	14·65	6·48

As compared with these figures, Mr. Armstrong gives the present cost of maintaining a 2-8-8-2 Mallet steam engine at 60 cents. per engine mile, without including many miscellaneous charges not shared by the electric locomotive.

On the Newport and Shildon line, a comparison of costs of repairs has been got out, and show as under, the steam engines being those which used to work this traffic:—

——	Material.	Wages.	Shop Expenses.	Total.	Miles Run between Repairs.	Cost per Mile.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.		d.
Steam No. 1682, 0-8-0 type freight	267 9 11	455 15 3	341 16 6	1,065 1 8	51,134	5·000
Steam No. 1139, 0-6-0 type freight	533 16 2	434 0 2	325 10 1	1,293 6 5	56,210	5·522
Electric No. 9, 0-4 + 4-0 type	98 9 9	258 5 1	193 14 5	550 9 3	100,101	1·316

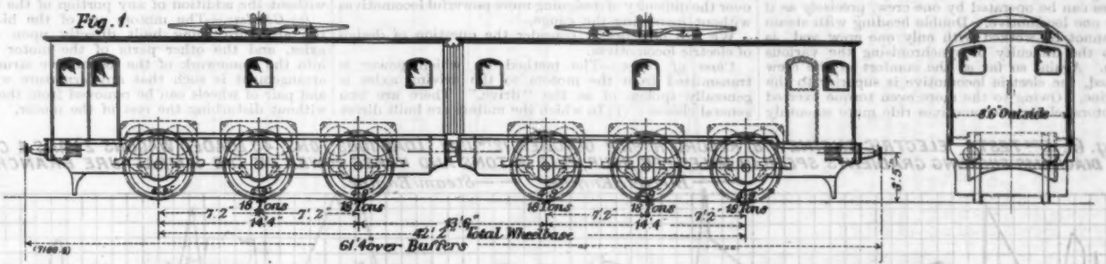
It may be noted also that the steam engine had no special renewals due to the boiler, otherwise the cost would have been very much higher. The shops required for maintaining a given number of engines need be much less elaborate than would be required for an equal number of steam engines. Further, it has been possible as a result of electrification—for example, on the Chicago, Milwaukee and St. Paul Railway—to lengthen engine divisions and eliminate intermediate engine depots. The latest passenger locomotives on this line are taken off for inspection after a mileage varying from 3,000 miles to 5,000 miles.

It may be argued that the whole story is not complete when one compares the maintenance cost of an electric locomotive with that of a steam engine as there is obviously a charge to be added to the electric for generating at the main station, and also transforming at the sub-stations, together with the equipment of the permanent way. It must be remembered that the cost of coal and water has not been added to the maintenance of the steam locomotive; therefore, to make the whole story complete, so far as a comparison between the two is concerned, you would have to take the maintenance of the steam engine together with the coal and water used, and compare that with the maintenance of the electric engine and rail equipment, and the total cost per unit; which, of course, includes coal and maintenance of generating and sub-stations. In the figures which we have for the North-Eastern Railway, the cost of coal and water used by the steam locomotive is somewhere equal to the unit as supplied to the electric locomotive together with the cost of maintenance of permanent way.

I have gone into the matter carefully with the figures obtained in regard to the Chicago, Milwaukee and St. Paul Railway, and it appears that the cost of coal on the locomotives is 40 per cent. greater than the cost of the power delivered to the locomotives; all expenses in connection with generation, transmission, conversion and distribution being included in the cost of power, together with capital charges and depreciation. Therefore, when this is taken into consideration, it would appear that the comparison of cost of maintenance as has been shown between the two types of locomotives, is at any rate, a fair one. In the case of the North-Eastern Railway, it can be shown, as mentioned above, that the cost of coal and water on the locomotive will balance the cost of the power delivered, including all the expenses before mentioned.

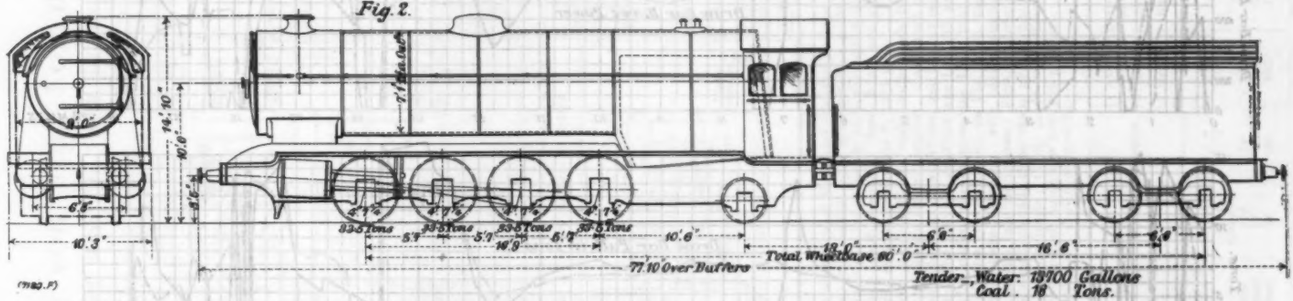
It will be seen that an additional saving of 40 per cent.

Fig. 1.



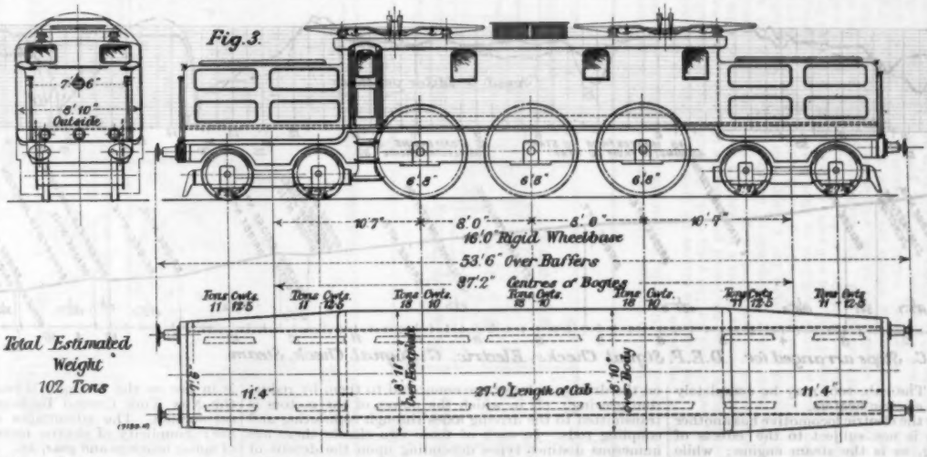
0-6-6-0 ELECTRIC FREIGHT LOCOMOTIVE. TOTAL WEIGHT ON DRIVING WHEELS, 108 TONS. ADHESIVE FACTOR, 4. TRACTIVE FORCE, 60,400 LBS.

Fig. 2.



0-8-2 LOCOMOTIVE. BOILER, 7 FT. 1 IN. DIAMETER; 20 FT. BETWEEN TUBEPLATES. FIREBOX, 9 FT. 6 IN. LONG × 8 FT. WIDE. GRATE AREA, 76 SQ. FT. TOTAL HEATING SURFACE. 4,600 SQ. FT. EVAPORATION CAPACITY, 55,200 LBS. OF WATER PER HOUR. CYLINDERS, TWO 26 IN. DIAMETER × 30 IN. STROKE. PRESSURE, 200 LBS. PER SQUARE IN. TRACTIVE FORCE, 60,000 LBS. AT 85 PER CENT. BOILER PRESSURE. ADHESIVE FACTOR, 5. TOTAL WEIGHT ON COUPLED WHEELS, 134 TONS. WEIGHT PER AXLE, 33 TONS 10 CWTS.

Fig. 3.



HIGH SPEED PASSENGER ELECTRIC LOCOMOTIVE.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, on December 16, 1921 (*slightly abridged*).

is shown on the Chicago, Milwaukee and St. Paul Railway, but this can be accounted for. The power supply is almost entirely generated in hydro-electric stations, and the water power resources consequently reduce the cost of the power delivered to the locomotives. Even though these costs for the North-Eastern Railway balance, the advantages gained by electric motive power increasing gross earnings, and decreasing operating and maintenance expenses, are sufficient to guarantee the adoption of electrification.

Wherever it may be necessary to have recourse to double heading, this can be more easily and satisfactorily done with electric than with steam engines; for two electric engines can be readily coupled electrically by a low-voltage control cable, and when this is done the two locomotives can be operated by one crew, precisely as if they were one locomotive. Double heading with steam engines cannot be worked with only one crew and is subject to the difficulty of synchronising the various operations. Again, so far as the comfort of the crew is concerned, the electric locomotive is superior to the steam engine. Owing to the more even torque exerted by the motors, electric locomotives ride more smoothly

dealing with the same work. It will be seen from the above that the one is within our present gauge and the steam unit considerably outside, and would be impossible to build unless a large amount of money were spent over widening the line and altering bridges and stations. It would require three of our two-cylinder 0-8-0 locomotives as shown in Fig. 11 on page 48 to do the work of this electric locomotive.

A good deal of controversy has taken place recently amongst the engineers and traffic superintendents as to the advisability and cost of adopting the International Berne gauge in this country, but the cost is so prohibitive that the question has been dropped for the present. Although electric traction would not get over the difficulty of dealing with larger coaches, it would get over the difficulty of designing more powerful locomotives without increasing the gauge.

We will now briefly consider the question of design of electric locomotives.

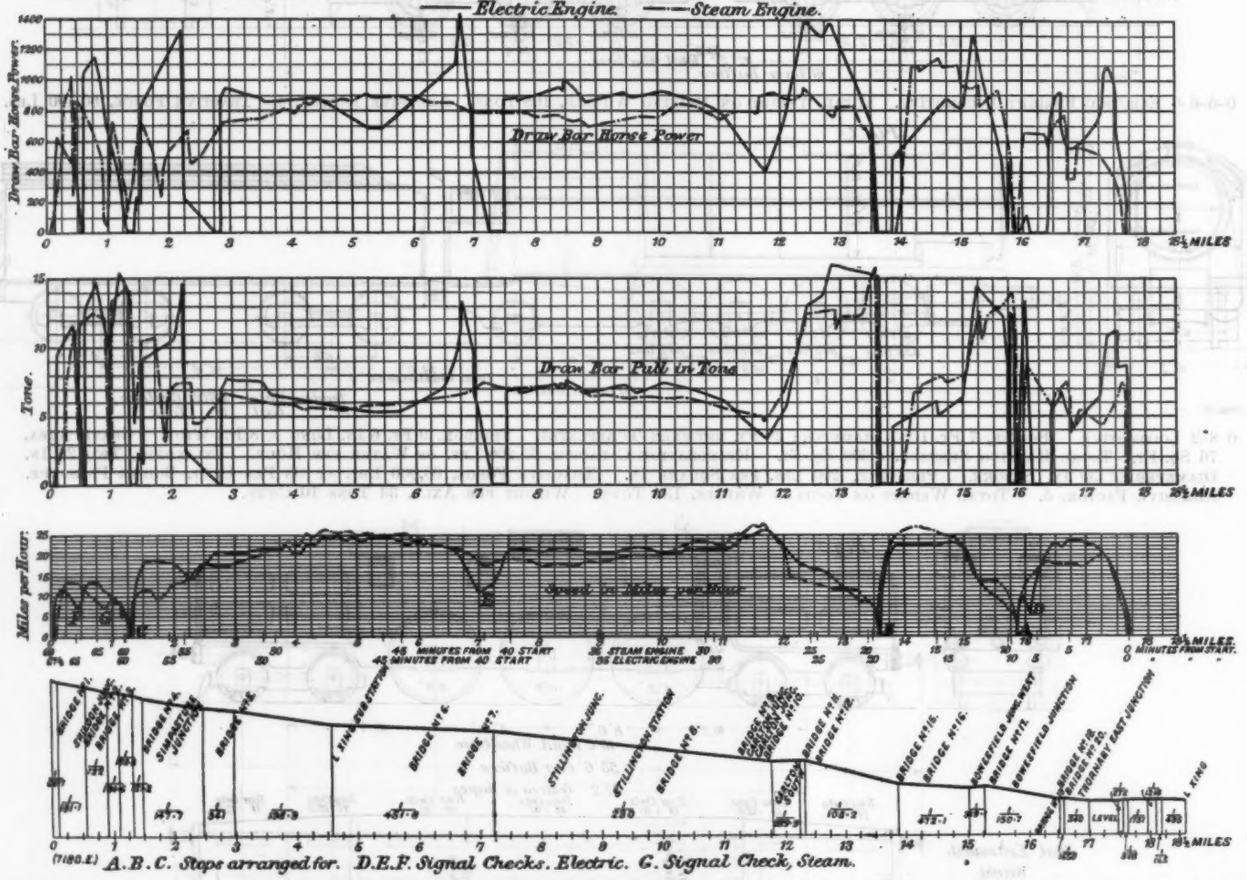
Class of Drive.—The method by which power is transmitted from the motors to the driving axles is generally spoken of as the "drive." There are two general classes: (1) In which the motors are built direct

clamps are interchangeable, and any spring may be removed without disturbing any part of the running gear. The arrangement is such that the axle, quill, pair of wheels and motor can be removed from the locomotive without disturbing the running gear. This drive secures all the advantages of a flexible gear in cushioning the transmission of torque, and lessens the vibration more effectively than the usual flexible gear construction and mounting. This drive is employed on the geared locomotives of the New York, New Haven and Hardford Railway, also the Chicago, Milwaukee and St. Paul.

Advantages of Quill Drive.—(1) The driving wheels are large; (2) the centre of gravity of the locomotive is high; (3) the deadweight on the track is reduced to a minimum consisting only of the wheels, axles, &c., without the addition of any portion of the motors.

(c) *Gearless.*—The motors are of the bi-polar type, the armature being built directly upon the driving axles, and the other parts of the motor being built into the framework of the locomotive structure. This arrangement is such that any armature with its axle and pair of wheels can be removed from the locomotive without disturbing the rest of the motor. This design

Fig. 6. 3RD TESTS. ELECTRIC ENGINE No. 8. RECORD No. 910. OCTOBER 12TH 1921. LOAD 1003 TONS, 40 LOADED WAGONS 2 VANS & CAR. DIAGRAMS SHOWING GRADIENTS, SPEED IN MILES PER HOUR, PULL IN TONS AND HORSE POWER ON THE SIMPASTURE BRANCH.



than steam engines. The cab, too, may be completely closed and fitted with electric heaters.

In very cold weather the electric locomotive has another advantage, in that it is not subject to the effects of radiation and freezing, as is the steam engine; while in hot weather the dangers of starting fires in the dry vegetation alongside the track by cinders falling from the engine, is non-existent. The cost of compensation to owners located along the route of a railway in this country, due to fires caused by the hot ashes discharged from the uptake of a steam locomotive is considerable. Again, the entire absence of smoke and dirt from the electric locomotive may be a decisive advantage in certain classes of terminal lines or where there are numerous or long tunnels to be traversed.

I have endeavoured to show in this paper the great advantage of being able to build or design a locomotive which by its tractive effort is able to keep a more uniform speed over the railway. In order to do this, it is necessary that you should be able to design a machine capable of giving you the power within the limits of the present load gauge. With a view to showing the difficulty of increasing the power of a steam locomotive without exceeding these limits as they stand to-day, I have worked out and show in diagram form in Figs. 1 and 2 an electric locomotive capable of exerting a pull of 15 tons which would haul a train of 1,000 tons up a gradient of 1 in 100 at 30 m.p.h., which is something I think we ought to aim at in the future; also a steam locomotive for

on the driving axles or are connected to them by reduction gearing; (2) in which the power of the motors is transmitted to the driving axles through connecting and coupling rods. In each of these two classes there are numerous distinct types depending upon the details of the drive.

CLASS 1. (a) *Motor with Reduction Gear.*—This is the most widely used method of transmitting the torque to the driving wheels. The motors are totally enclosed, each driving an axle through single reduction gearing, a pinion being mounted on the end or on each end of the armature shaft, and meshed into a corresponding gear wheel, mounted on the running wheel axle. The motors are suspended by a cross suspension bar with bearings and re-action springs. These, with the motor suspension bearings on the axle, provide the motors with four points of suspension. This particular design, which is the ordinary double bogie articulated type, is widely used for freight traffic, and is the same as that used on the Shildon-Newport Electrification, North-Eastern Railway, and others in the States and on the Continent.

(b) *Quill Drive.*—The motors are mounted rigidly between the frames. Each motor is geared to a quill centred in bearings in the motor frame and surrounding the driving axle. The axle and quill are concentric. The quill is connected to the driving wheels by long helical springs which are clamped rigidly at the ends in castings which are bolted, one to the quill flange, and the other to the driving wheel. All springs with

is in use on the Chicago, Milwaukee and St. Paul and the New York Central Railways, and is giving every satisfaction. The advantages claimed for this design are: Simplicity of electric motor owing to the absence of motor bearings and gear, &c. Facility for examination of motor and removal of armature for repairs if required. The mechanical arrangement of the complete locomotive is said to possess the required flexibility and balance to enable it to run at any speed equally well in either direction without tendency to oscillate or spread the track.

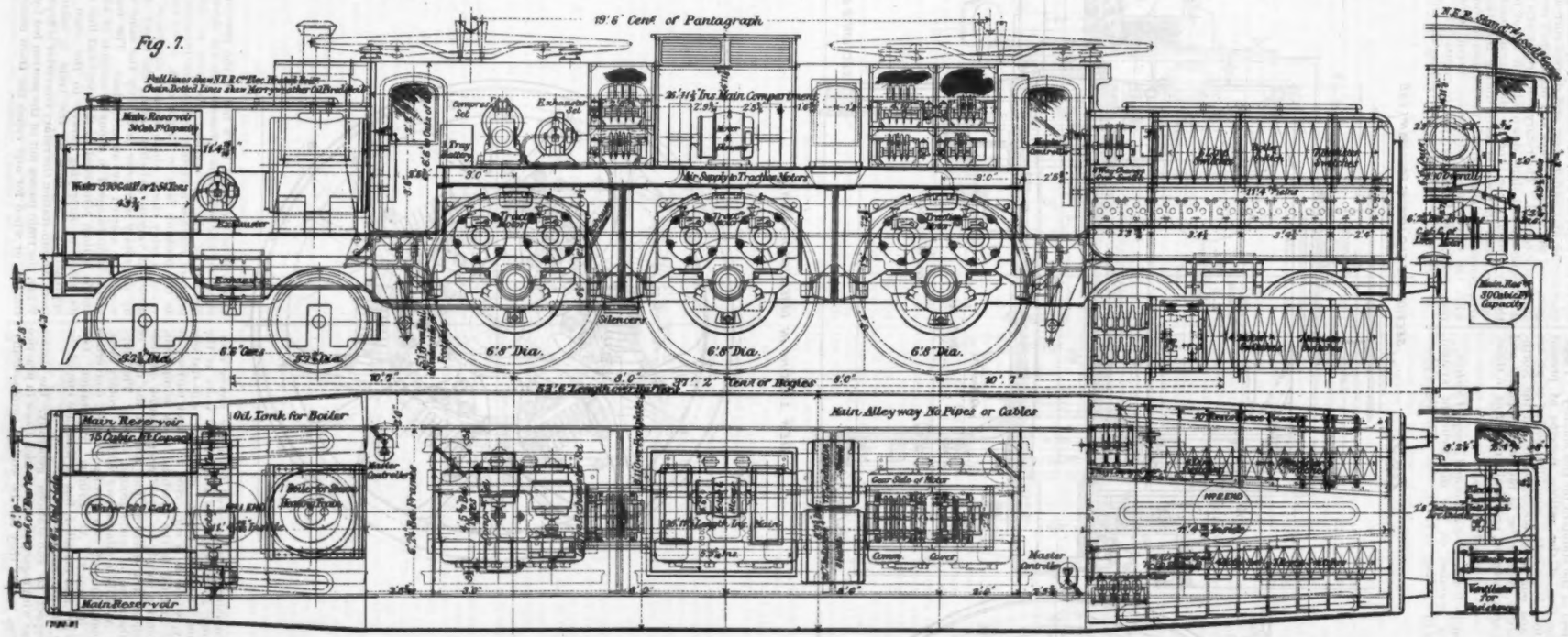
CLASS 2.—In this class the rotary motion of the motor armatures is transmitted to the axles by cranks on the motor shafts or on jackshafts driven by the motors, and by connecting rods coupling these cranks with crank-pins on the driving wheels. The principal advantage of this method of drive is that the exact position of the motor in relation to the driving wheels is at the disposal of the designer, and he is therefore free from the restrictions imposed upon him by the necessity for getting the motors into the space between the flanges of a pair of wheels as in all locomotives of Class 1, and is therefore enabled to use large motors and place them in the most convenient position in the locomotive.

This method of drive has not been employed at all in this country. In the United States there are a few examples, viz., the locomotives on the New York section of the Pennsylvania Railroad, others of a different design on the Norfolk and Western Railroad and an

4-6-4-TYPE ELECTRIC PASSENGER LOCOMOTIVE FOR THE NORTH-EASTERN RAILWAY.

CONSTRUCTED FROM THE DESIGNS OF SIR VINCENT L. RAVEN, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

Fig. 7.



experimental locomotive designed by the Pennsylvania Railroad for the electrification of the Altona grade. The general opinion in the United States seems to be more in favour of designs which come under Class 1.

On the Continent, notably in France, Switzerland, Italy, Germany, Austria and Sweden, the connecting-rod drive in one form or other is almost universal. Up to the present electrification in these countries has been carried out mainly on the single-phase or three-phase system, and Continental engineers consider that the additional complications caused by the introduction of cranks and coupling rods are more than compensated for by the advantage of having a free hand with the motor design. A large number of designs have been worked out. Some have proved quite satisfactory, others have given rise to a good deal of trouble. In most cases the trouble has been eliminated by strengthening up special parts such as crank pins, Scotch yokes, &c., and by introducing a certain amount of flexibility into the connections between the motors and the crank-shafts.

The freight locomotives on the North-Eastern Railway were designed and built at the Locomotive Works, Darlington. They are shown in Figs. 4 and 5 on Plate II and in Fig. 12 on page 48. They are arranged to haul trains weighing 1,400 tons at a speed of not less than 25 m.p.h. on the level. They may be described as articulated truck locomotives in which the tractive effort is transmitted through the truck frames. The motor equipment of each locomotive consists of four totally-enclosed motors, each driving an axle through single reduction twin gearing. The motors are suspended by means of a cross-beam suspension bar with bearings and reaction springs. These, with the motor suspension bearings on the axle, provide the motors with four points of suspension.

The four main motors are fitted two in each bogie, and are wound for 750 volts each, the pair of motors in each bogie being connected permanently in series. The four main motors of each locomotive thus form two units, which are controlled on the usual series parallel system. Each motor is capable of developing 275 b.h.p. at a speed of 20 miles for 1 hour with forced ventilation. The motor equipment is capable without injury of exerting a torque sufficient to skid the wheels on any conditions of rail, and will exert an average pull of 28,000 lb. at the tread of the wheels when starting under normal conditions of rail. The maximum pull at the tread of the wheels is, of course, considerably greater than this.

The driving wheels are eight in number, measuring 4 ft. diameter; wheel arrangement, 0-4 + 4-0; length of fixed wheel base, 8 ft. 9 in. per truck; total of both trucks, 27 ft. There are four axles and the total weight is 75 tons. The horse-power of motor for 1 hour rating is 275, and for continuous rating, 182. This design of locomotive appears to be generally suitable for dealing with goods and mineral traffic up to the necessary speed.

The latest type of heavy mineral and goods steam locomotive (Fig. 13 on page 48) built on the North-Eastern Railway in 1919, usually known as the 0-8-0 class, is a three-cylinder engine with 200 lb. boiler pressure. It has a maximum tractive effort at 85 per cent. boiler pressure of 41,070 lb. or 18·3 tons. Weight on coupled wheels, 71 tons 12 cwt. Total weight ready for running, 115 tons 14 cwt. This engine was brought before the public by trials carried out on the North British Railway, between the Bridge of Earn and Glenfarg, where a load of 755 tons was hauled up a gradient of 1 in 75 at an average speed of 12·8 miles an hour, through a distance of 7 miles. (Full details of these trials are given in *The Railway Gazette*, September 9, 1921.)

I thought it advisable to make some trials between this engine and the electric engine; these were carried out on the Shildon and Newport line, and I give the results hereunder: The heaviest gradient was 1 in 103, and the total weight hauled in each case was 1,003 tons. The gradient of the line is shown in Fig. 6 on page 40. These tests were arranged with dynamometer car attached to the load as follows: First, a through run without a stop; second, three stops at the bottom of the heaviest gradients; third, made with three stops with the whole train upon the heaviest gradient.

The results are shown as under:—

—	Steam.	Electric.	Average Draw-bar Horse-Power.	
			Steam.	Electric.
Distance ..	miles 17¼	17¼	—	—
1st test (time) ..	minutes 56¼	54	862	870
2nd test (time) ..	77	53	602	883
3rd test (time) ..	68	60	682	716

Drawbar Pull Test (Fig. 6).—The relative maximum strength of the two engines is in proportion to the weight on the driving wheels:—

	Tons.
Weight on drivers of electric	75
Weight on drivers of steam	72

It will be seen that they are practically equal so far as adhesive force is concerned, and the adhesion determines the maximum possible pull. The turning effort of the motors on the electric locomotive produces tractive effort up to the limit permitted by the adhesive weight. In the case of the steam engine, the steam pressure, acting on the piston, produces similar results. Therefore, it may be said that the two locomotives were designed to be of equal strength. From the tests made, it will be seen that the electric engine handled the load better than the steam; there was less time taken. The steam engine was not able to maintain itself, owing to the fact that it was not able to keep up steam. The fire had to be cleaned out after the second trip, consequently terminal time was wasted. The electric engine, after completing the three trips, could have gone on doing this work indefinitely.

The North-Eastern Railway have also designed an electric passenger engine which is being built and erected in their Locomotive Works at Darlington, the electrical equipment being provided by the Metropolitan-Vickers Company. This engine is arranged to haul a 450-ton express passenger train at an average speed of 65 m.p.h. The running gear is designed for a maximum safe speed of 90 m.p.h., without doing damage to the mechanical portion of the locomotive, which is of the 4-6-4 type (as shown in Fig. 7, annexed), and consists of main frames mounted on three driving axles with three pairs

of driving wheels, 6 ft. 8 in. in diameter, and a four-wheel bogie at each end; cab and sloping ends are rigidly fixed to the main frames, and are provided with the necessary supporting members for carrying the auxiliary and control equipment. The current is collected from the overhead trolley by means of pantagraphs mounted on the roof at each end of the centre compartment.

The main traction motors which are of the twin armature type, are rigidly fixed to the main frame of the locomotive, and transmit the torque to a gear wheel mounted on a hollow shaft or quill drive. The high-tension apparatus is located in one of the sloping ends (as shown in Fig. 7 on page 41); the other sloping end contains an electric boiler for supplying steam for train heating. The capacity of the locomotive will be 1,800 h.p., 1 hour rating or 1,260 h.p. continuous rating. Figs. 8 to 10, annexed, show the assembly of the quill drive.

The various locomotives referred to do not all operate on the same system of electrification, and the principle variations are covered by the following examples:—

Chicago, Milwaukee and St. Paul Railroad.—The locomotives operate by direct current at 3,000 volts on the trolley. A three-phase power supply is generated by hydro-electric power stations, and raised by means of step-up transformers to 100,000 volts. High-tension transmission lines take it to the various sub-stations, which are located at intervals along the track. In the sub-stations, step-down transformers are used to lower the voltage to 2,200 volts alternating current, and the power is then converted to 3,000 volts direct current by means of motor generators.

New York, New Haven and Hartford. Single-Phase and Direct Current.—These locomotives operate on a trolley voltage of 11,000 volts alternating current, 25 cycles or 500 volts direct current. On the company's lines the trolley voltage of 11,000 volts is reduced by means of a main transformer located on the locomotive, to approximately 300 volts to suit the single-phase series motors. The speed characteristics and stability of the single-phase motors are very similar to those of the direct-current motors. These locomotives also run over the New York Central road, approximately 12¼ miles into the New York Central Station on the third-rail direct-current 600 volts. On this section the main transformer is simply cut out, and grid resisters are used for starting as in the case of an ordinary direct-current locomotive.

Italian State Railways.—The power supply for the three-phase system is 3,000 volts and 3,500 volts, with cycles of 15 and 16⅔ respectively, which is delivered direct to the locomotives by means of two overhead trolley wires for two of the phases, and the third phase transmitted through the running rails. The constant speed feature of these locomotives which is independent of load or grade, has worked out very satisfactorily, and the inherent regenerative characteristics of the induction motors are ideal from a regeneration braking point of view. The change from motoring to braking as the engine begins to descend the grade takes place automatically, no action being required by the drivers.

Norfolk and Western Locomotives.—The split-phase locomotive collects power from a single-phase trolley at 11,000 volts, in a similar manner to the single-phase locomotives and transforms the power from single-phase to three-phase, using three-phase induction motors so that this locomotive has similar characteristics to the three-phase locomotive described above.

Standardisation.—The Advisory Committee which was appointed by the Ministry of Transport have now submitted their final report in which they have definitely recommended the adoption of the 1,500 volts direct-current system as the standard for this country. Therefore the question of the various systems at present existing is to a large extent simplified so far as we are concerned, and our latest electrification on the North-Eastern Railway, both so far as railway equipment and locomotives are concerned, practically conforms to these.

Sub-Stations.

North-Eastern Railway—Shildon and Newport Section.—This line is operated on the direct-current system, employing a line voltage of 1,500 volts. The three-phase high-tension current is received from the power company's system at 20,000 volts and 11,000 volts at the Aycliffe and Erimus rotary converter sub-stations respectively, where it is converted to direct current at 1,500 volts, and fed to the overhead track equipment. The high-tension supply to Aycliffe sub-station consists of an overhead transmission line, and in the case of Erimus substation of underground cables. The sub-station at Aycliffe contains two 800-kw. rotary sets, each set consisting of two 400-kw. rotary converters connected in series. At Erimus sub-station two rotary sets are also installed, but in this case one of the sets is of 1,200 kw. capacity.

With respect to sub-stations generally, the latest development with regard to these, which I saw in practice in the States, is that they can be worked automatically. Each automatic sub-station contains a single rotary converter, together with the necessary alternating current transformer and switch gear and direct-current switch gear, and the various relays and other small devices for automatic control. The rotary converter starts up when it is required, and shuts down when it is not required; thereby reducing the time of idle running and cutting out the losses that would occur during that time. The arrangement of the automatic mechanism in conjunction with the direct and alternating-current switch gear provides for the following cycle of events:—

If a train or a single car is approaching the sub-station this will be indicated by a fall of the pressure on the overhead line which is connected to the direct-current bus-bar of the sub-station. As soon as this fall of pressure reaches a certain value, for instance, as soon as the pressure falls to 75 per cent. of its normal full value, a relay closes which starts a succession of movements of various switches having the effect of starting up the rotary converter in exactly the same way as it would be started by an attendant. The rotary converter is up to speed in about 35 seconds or 40 seconds, and it is then connected to the overhead line and takes its share in supplying power to the train which is approaching. So long as the train is taking power from the sub-station the rotary converter is kept running. When the train passes out of the section fed by the sub-station, or when for any cause the train ceases to take

Fig. 8. VIEW LOOKING IN DIRECTION OF ARROW "C"

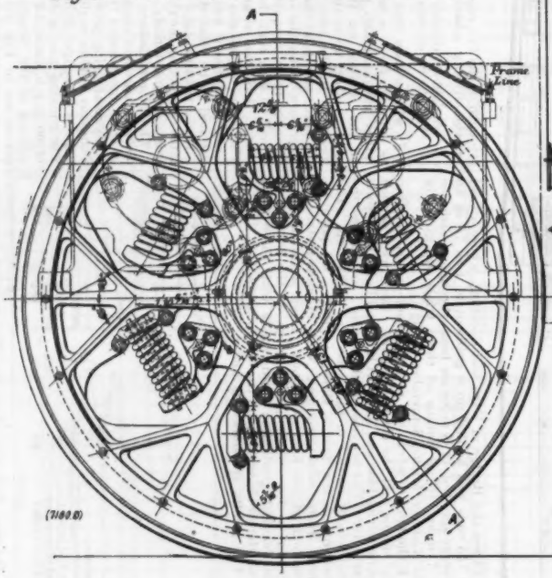
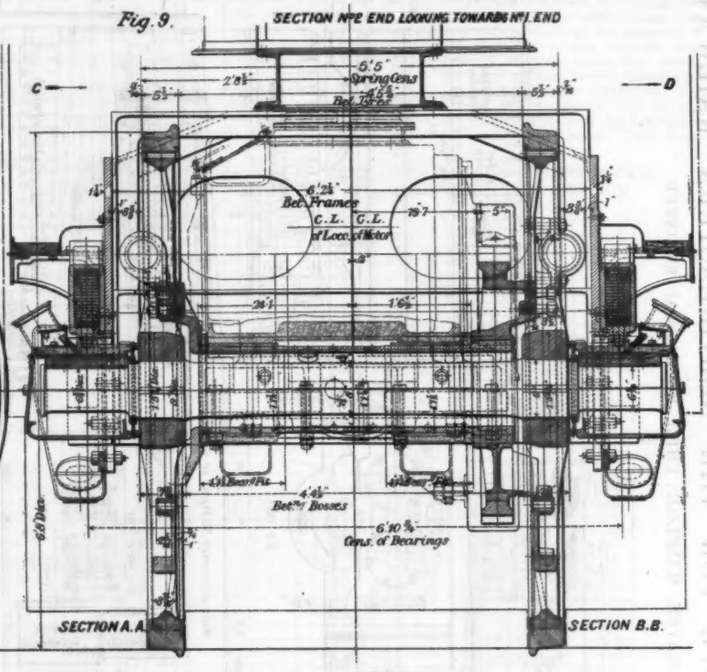
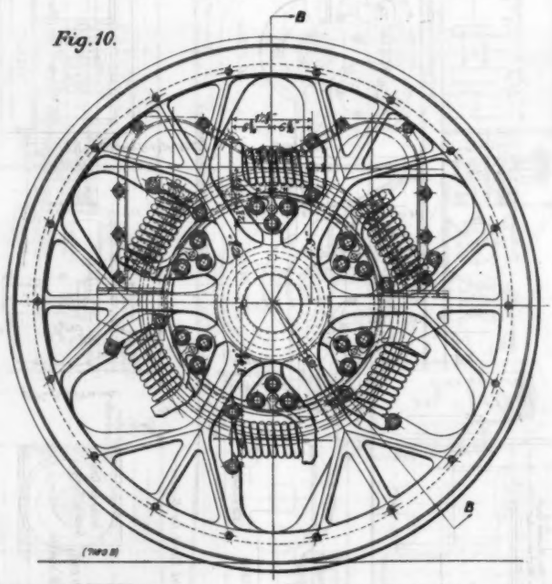


Fig. 9. SECTION N°2 END LOOKING TOWARDS N°1 END



VIEW LOOKING IN DIRECTION OF ARROW "D"

Fig. 10.



current, another relay in the sub-station comes into operation and sets in motion a mechanism which is so arranged that after a definite interval of, say, 4 minutes or 5 minutes, the rotary converter is shut down if, in the interval of 4 minutes or 5 minutes, no further supply is required.

This delayed action is necessary to prevent the rotary converter being shut down too frequently, for example, whenever the power is switched off the train for a halt at an intermediate station. The rotary converter having been shut down can then be started up again in precisely the same way as soon as another train approaches the sub-station and requires a supply. In addition to the various movements, &c., necessary for carrying out this programme, other protective devices are provided which guard against damage to the rotary converter under abnormal circumstances, such as short circuits on the line, overheating of the windings, or of the bearings in the rotary converter, &c. Thus, the sub-station attendant is entirely eliminated, and as, in many instances, sub-stations have to be in service for more than 16 hours a day, the introduction of automatic working eliminates the three shifts of attendants. All that is necessary is that the sub-station as a whole, including the automatic relays, should be inspected at regular intervals, which may be once a fortnight or perhaps once a week, depending upon circumstances.

I went very carefully while I was in the States into the question of the cost of running sub-stations. This cost is generally expressed in so many pence per unit sent out from the sub-stations, and the figure naturally depends upon the capacity of the sub-station, as it costs almost as much for an attendant to look after a small as a large plant. On the Chicago, Milwaukee and St. Paul Railway, where the sub-station plant is of considerable magnitude, the total cost of (including attendants) maintenance and supervision only worked out at 0·048*d.* per unit delivered. Of this total the cost of attendants alone is 0·0315*d.*, which shows that this is the principal item in the total cost. If the sub-stations were worked automatically—which is more than a possibility as the method seems now thoroughly well established in the States—the total cost of running the sub-station on that line would not be more than about 0·02*d.* per unit delivered.

Electrification would naturally come by degrees and would be adopted first on lines where the densest traffic existed. This would not only be around large cities, but would extend over considerable areas between important industrial centres and congested trunk lines. It is generally known that other countries have extended in the way of electric traction, far ahead of this country, probably on account of cheaper methods of generating electric power; but I see no reason why electricity should not be generated by use of waste heat, and methods of this description, with such economy as to enable us to compete with electricity generated by water power abroad, and it would be unfortunate if for want of cheap power we were behind other countries in important developments such as these.

I should like to emphasise very particularly the question of cheap generation of electric power, as this is one of the governing factors in promoting electric traction on railways. I believe that supply companies should be able to generate this power much cheaper than a railway company, as they ought to be able, generally, to get a much better load factor; and the desire should be that electric current will be produced at such a cost as to ensure that the price for current, plus the maintenance of the railway equipment shall not exceed the present coal and water bill.

RAILWAY BRAKES FOR HEAVY TRAFFIC.*

CONTROL OF TRAINS CONSIDERED IN RELATION TO INCREASES OF WEIGHT AND SPEED, COMBINED WITH REDUCED HEADWAY.

By ALAN WOOD RENDELL, M.Inst.C.E.

In his opening remarks the author draws attention to the stresses arising from the forces employed to accelerate and decelerate moving masses such as railway trains, and observes that while the acceleration of such masses has always received much consideration, the deceleration does not seem to have been given the attention it deserves as an important factor in improving the traffic facilities on congested roads by reducing the headway between trains. The stresses arising from the forces employed to accelerate or decelerate a moving mass are briefly compared and reviewed, and attention is drawn to the average rates per second, reached in acceleration, which are shown to be only about half the average rate per second which can be reached in deceleration. This difference will become more marked as the speed and weight of railway vehicles increases, provided the force developed in the brake system is increased in due proportion.

There are three main factors governing the rate of deceleration obtainable in a brake system, viz.:—

(1) The brake shoe pressure and coefficient of friction.

(2) The maximum brake cylinder pressure, and the time in which the maximum pressure is developed in the brake cylinder in every vehicle in the train from the moment of application.

(3) The efficiency of the brake rigging in multiplying and transmitting this pressure to the wheels through the brake shoes.

Dealing with the first, the author explains that, although the coefficient of friction between the brake shoe and steel-tyred wheels varies almost inversely as the speed, under the same conditions of pressure and speed the coefficient may range from a minimum of 7·8 per cent. to a maximum of 14·7 per cent., or from a minimum of 16·7 per cent. to a maximum of 26·9 per cent., according to the type of brake shoe employed. To obtain the best results, the actual bearing surface of the brake shoes against the tyre of the wheel should be maintained at the maximum obtainable for the duration of each brake application, since the greater the pressure per square inch of bearing surface, the lower will be the mean coefficient of friction. In consequence, the use of two brake shoes per wheel is to be advocated, especially in view of the ever increasing axle loads now carried.

Referring next to the question of brake-cylinder pressure and its rate of propagation throughout a train the author lays stress on the importance of the first admission of an approximately equal degree of pressure to the brake cylinders on all the vehicles of the train being effected within the shortest possible time. This is necessary in order to prevent the vehicles at the rear of the train running on to those in front and pushing them forward, which not only retards the rate of deceleration, but also tends to breakages of couplings. The subsequent rises in pressure should also be distributed as evenly as possible throughout the whole length of the train. Diagrams of various applications are appended. Attention is also drawn to the desirability of keeping the size and weight of brake apparatus within reasonable limits, which, with the heavy units of modern trains can best be accomplished by employing high brake-cylinder pressures, as otherwise either the size of the brake cylinders must be increased to inconvenient dimensions, or a number of brake cylinders must be installed on each vehicle, complicating amongst other things the arrangement of brake rigging. Attention is drawn to the delay in the development of pressure in the brake cylinders, and loss of power due to "false piston travel," or the movement of the piston in the brake cylinder before it does useful work.

This introduces the third important factor, viz., the efficiency of the brake rigging, and it is one which has perhaps been less regarded in the past than any other. The principal factors which conduce to increase the ineffective movement in the brake rigging are: the manner in which the brake shoes are hung in relation to the wheels; the wear of the pins and the spring of rigging due to weak design; and the movement of the frame of the vehicle on its springs. This travel is multiplied at the brake cylinder piston in proportion to the leverage adopted. It is important therefore that the leverage be kept within the lowest possible limits, and it is recommended that the Continental practice of a ratio of 8 : 1 be not exceeded. It is also essential to good braking to proportion the brake levers so that the pressure developed in the brake cylinder shall be equally distributed to all the brake shoes of the vehicle, otherwise the effort of retardation will be concentrated on one pair of wheels, causing them eventually to skid, whilst the others are free to revolve.

Diagrams are given showing the variation of pressures on the rails between different wheels of a vehicle in "service" and "emergency" stops, and also of various methods of suspending the brake shoes, so as to obtain the greatest possible efficiency.

A useful formula for comparing stops in terms of the actual average deceleration obtained in percentage of the acceleration of gravity, or 32·2 ft. per second, is given, and the paper concludes with a few general remarks as to the importance, to the most economic handling of rapid transport, of a careful study of the problems of improved deceleration.

TRIALS IN CONNECTION WITH THE APPLICATION OF THE VACUUM BRAKE FOR LONG FREIGHT TRAINS.

By Sir HENRY FOWLER, K.B.E., M.Inst.C.E., and HERBERT NIGEL GRESLEY, C.B.E., M.Inst.C.E.

It is now more than fifty years since the necessity of continuous automatic brakes for passenger trains was fully realised. To-day in this country there are two in use, the Westinghouse brake and the automatic vacuum brake.

In early days the type of vacuum brake employed was the "straight vacuum" brake. This was one of the earliest brakes capable of being applied by creating a vacuum by means of an ejector and released by destroying the vacuum. The pressure acting on the brake pistons or diaphragms could be varied and the maximum pressure obtainable was independent of the travel of the brake piston. As the ejector only worked when the brake was needed, this type was economical in steam consumption. It will be seen, however, that it was non-automatic, and any failure of the ejector or rupture of the train pipe rendered it impossible to apply the brake, and furthermore no indication of failure was given to the driver until he found the brake useless. It was therefore imperative that a brake should be so constructed that any failure should result in automatically applying the brake. This made it necessary to maintain a vacuum in order to keep the brake off.

The train apparatus is simple, each vehicle having a train pipe coupled up with cylinders in which the movement of pistons or diaphragms operates the brake. This arrangement proved satisfactory in dealing with the trains of the length met with in this country to within the last few years. Due, however, to steadily-increasing length and weight of passenger trains, developments consisting of accelerators and more powerful ejectors have been introduced. A fresh aspect of the brake problem is presented by the growing tendency to use the continuous brake for certain classes of freight traffic.

The main difference between braking freight trains and passenger trains are briefly as follows: (*a*) The greater length of freight trains; (*b*) the necessity of running loaded and empty wagons together in freight trains; (*c*) even if screw couplings are used, the need of quickly coupling and uncoupling when shunting will probably result in the couplings being screwed up less tightly than in passenger trains. This tendency to couple loosely enhances the need for a smooth and uniform action of the brake throughout the train.

With a view to ascertain the suitability of the vacuum brake for long freight trains, a series of trials was carried out during the summer of 1919 by the authors on the Great Northern Railway between Peterborough and Firsby. The following conditions were laid down as a standard of satisfactory performance:—

That trains of 100 wagons, close coupled, must be stopped:—

(1) By emergency applications without shock and without any risk of parting the train.

(2) By service applications without shock or risk of parting, and in such a manner that the train could be restarted immediately after coming to rest.

(3) That the speed of the train could be reduced as required.

The train consisted of Great Northern Railway 8-ton covered vans fitted with the Great Northern Railway standard vacuum brake, with the Westinghouse Brake Company's accelerators and reducing nipples. In addition to these the train included three Midland Railway 6-wheeled vans carrying the necessary recording instruments. One of these was placed at the front of the train, one in the middle, and one at the rear. All the vans were unloaded and provided with screw couplings. The brakes were tested for leakage before the trials, and the travel of the brake pistons adjusted as required. The instruments comprised speed recorders and duplex vacuum recorders. The latter instruments (one of which was placed in the front, middle and rear vans) recorded the pressure in the train pipe and brake cylinder reservoir.

The average retarding force is the basis usually adopted for comparing brake stops. This force is conveniently expressed as a percentage of the weight of the train, and in the calculations, the weight of the train is taken as the gross weight of the train increased by the equivalent rotary inertia percentage, which was found from calculation to vary from 10·4 per cent. to 10·7 per cent. of the weight of the train. The forces concerned, inclusive of brake power, friction and gravity, are assumed to be acting uniformly throughout the stop.

The stopping efficiency for the different trains has been found by expressing the actual average retarding force as a percentage of the average retarding force corresponding with the speed-distance curve which was plotted from the results obtained from a train of 63 vans which was adopted as a standard for comparison.

Effects observed on the Stopping of Various Trains under Different Conditions.—With the sixty-three-van train, fitted with accelerators and standard reducing nipples, all emergency stops made under these conditions were satisfactory. It was found necessary, in making speed reductions or service stops, to apply the brake gradually, otherwise the accelerators operated, and unless the speed was high, say over 30 m.p.h., the train came to a stand before the brakes could be released.

The 80-van train was made up by attaching 9 vans at the front of the previous 63-van train and 8 vans at the rear; these vans had not accelerators or reducing nipples. The records of these stops were spoilt on account of the effect of the shocks on the instruments, and it was decided to abandon further trials with trains not completely fitted with accelerators.

The 82-van train was fitted with accelerators and standard reducing nipples throughout. At speeds above 40 m.p.h. the stops were fairly smooth but between 30 m.p.h. and 40 m.p.h. there was a rough jerk just before stopping, and for stops from 20 m.p.h. to 30 m.p.h. the jerk was very severe just before coming to rest. The stopping distances of this train were almost identical with that of the 63-van train. Emergency stops were tried with the working vacuum reduced to 16 in. These were fairly smooth except at the lower speeds, but the stopping distance was increased by about 20 per cent.

With the eighty-two van train specially fitted with accelerators and specially reduced nipples, the effect of the reduced nipples was to make the stops at all speeds quite satisfactory as regards being smooth, but increased the stopping distance by about 25 per cent.

With a one hundred and one-van train, fitted with accelerators and specially reduced nipples, the emergency stops were quite satisfactory as regards being smooth, but compared with the standard of comparison—63-van train—the stopping distance was increased by about 35 per cent. Emergency stops were also made working with a 16-in. vacuum. In this case the stops were very smooth, but the stopping distance compared with the standard was increased approximately by 50 per cent.

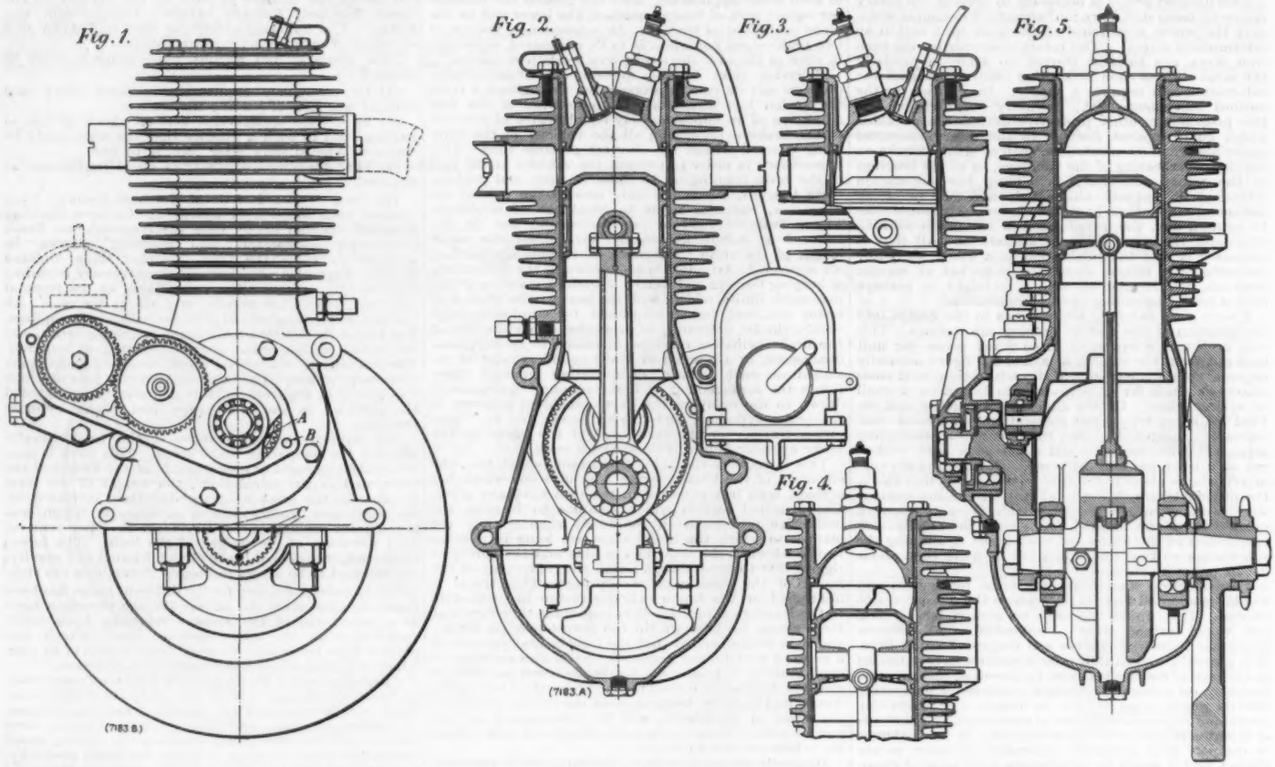
Tables are given showing particulars of the various trains experimented with, and the speeds, stopping distances, and efficiency of the stops, &c., the relation between the speed and the stopping distance for different trains is also shown graphically. Curves are given showing the rise in effective pressure on the brake pistons at any instant after the application of the brake, and particulars of observations made to ascertain the time taken to release the brakes on the various lengths of trains tested.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—Dr. Bryson Cunningham has been appointed lecturer on Waterways, Harbours and Docks at University College, for the present session. He will begin a course of lectures on Tuesday, January 24, at 4 p.m., this course, which will be continued on Tuesdays and Fridays at 4, deals with ports, harbours, docks, inland waterways and maritime structures. The fee for the course is 3*l.* 3*s.* Full particulars can be obtained from the Secretary, University College, London, W.C. 1.

* Abstracts of two papers read before the Institution of Civil Engineers, on Tuesday, January 10, 1922.

SINGLE-CYLINDER AIR-COOLED SLEEVE-VALVE MOTOR-CYCLE ENGINE.

CONSTRUCTED BY MESSRS. BARR AND STROUD, LIMITED, ENGINEERS, GLASGOW.



THE average engineer when first confronted with the question of the employment of some form of sleeve valve in petrol engines is apt to suggest that although the idea has very decided attractions, it is probable that both cooling and lubrication will give trouble. That with suitable design these ideas are inaccurate is, however, sufficiently shown by the very considerable extent to which the sleeve-valve engine has been employed in automobile work. As will be generally known, several makes of car have used engines of this class with marked success. These car engines are, we think, in all cases water cooled and the whole subject has certainly been carried forward by the introduction of the Barr and Stroud air-cooled sleeve-valve engine for motor-cycle work. Messrs. Barr and Stroud's engine is made under the Burt and M'Collum patents, and is, we think, the first application of an air-cooled sleeve-valve engine to automobile work.

It is, perhaps, hardly necessary here to enter into the advantages of a sleeve-valve construction once its practicability is admitted, but it will, perhaps, be allowable briefly to mention a few of the main points which can be urged. The most obvious of these is the silence with which the valve mechanism operates as compared with the poppet mechanism of any four-stroke cycle engine. Poppet valve noise is to some extent in inverse ratio to efficiency since it is possible to reduce the noise by so forming the operating cams that the valves meet their seats when moving comparatively slowly. This, however, can only be done with sacrifice of power production and efficiency. As against this the sleeve construction gives remarkable control over the gas distribution. The inlet ports can be opened more rapidly than is possible with poppet-valves, while the same thing can be done with the exhaust ports, enabling exhaust to be delayed and a longer effective stroke obtained. The simplicity of the cylinder head with sleeve-valve construction also allows great freedom in the fixing of the shape of the combustion chamber and the situation of the ports gives a high degree of gas turbulence and good combustion. The number of parts in the engine is also considerably reduced, while springs are eliminated.

The Barr and Stroud motor-cycle engine is of the single cylinder type, the bore being 70 mm. and the stroke 90·5 mm., giving a capacity of 349 cc. The nominal output is 3 h.p., but owing to the high volumetric efficiency and low friction losses a much higher power than this can be obtained over long periods. The power curve rises steadily in an almost straight line to over 4,000 r.p.m., at which 7 h.p. are developed. The total weight of the engine is 50 lb. The general lay-out and appearance are well shown in the outside elevations and sections given in Figs. 1, 2 and 5, above, and the views given in Figs. 6 and 7, opposite. As will be seen from Figs. 2 and 5, the cylinder and upper part of the crank case are a single casting, the loose lower half of the crank being held in place by four set screws. The cylinder unit is of cast-iron. Brackets are formed in the crank chamber, to which the housings of the crankshaft main ball bearings are secured. These can be seen in Fig. 2, while a good view of the bearing housings is given in Fig. 8.

The cylinder head is detachable and is held in place by six set screws. The head projects into the cylinder and is provided with an expansion sealing ring near its lower end. The head as shown in Figs. 2 to 5 is fitted with the sparking plug and with a mushroom compression release valve, which can be used for priming. This valve is controlled by a flat spring as can be seen in several of the figures. There are no connections to the head except the sparking plug wire, so that it can be removed when necessary without trouble. The crankshaft, as is well shown in Figs. 2, 3 and 8 is fitted with ball or roller bearings throughout. It is a solid forging, and the big end is threaded on from one end. After it is in place the bearing rollers are put in position and retained by split bronze side-plates held together by steel locking ring. When the big end bearing has been assembled two balance weights are pressed on the tenoned cranks and secured by bolts and nuts. The main bearings are of the Skefko type, and the housings are furnished with projecting lugs to bolt to the crank chamber brackets as already described. The fly wheel, which is 11 in. in diam. and which carries a chain sprocket, is fixed on a taper at the end of the crankshaft. It is the only moving part which projects from the interior of the engine. A gland is fixed at this end of the shaft to prevent oil leakage.

The sleeve is of close-framed cast-iron, and as will be clear from the sections of the engine, the piston works inside it so that the sleeve is actually a moving cylinder liner. A general view of it is given in Fig. 9, opposite. The sleeve has both a reciprocating and rotating motion, and this feature would appear a valuable one. It must tend to prevent grooving, and must materially assist in the distribution of the lubricant. The body of the sleeve is ground inside and out, and is $\frac{1}{32}$ in. in thickness. The base is thickened up and carries a pin at right-angles to the axis as shown in Fig. 9. The sleeve is driven through this pin, which engages with the inner member of a ball and socket joint which is located within the half-time wheel. This is the larger toothed wheel which can be seen in Fig. 7 and which is driven by a pinion keyed to the crankshaft. The arrangement is shown in section in Fig. 5. As will be seen from this latter figure the shaft which carries the half-time wheel runs in Skefko ball bearings. The ball and socket coupling which embraces the driving pin on the sleeve can be seen in section in Fig. 5. It is mounted eccentrically and at a slight angle from the vertical. The driving pin is a sliding fit in the inner member of the coupling, and as the half-time wheel rotates the pin has a slight sliding motion in the coupling. It will be clear that the effect of the whole arrangement is that as the half-time wheel rotates the sleeve is carried up and down, and at the same time has a rotational movement on its axis, any point on the outer surface of the sleeve moving in an approximately elliptical path, the major axis of which is vertical.

The sleeve has five ports cut in it the shape of which is clearly shown in Fig. 9. The cylinder has six ports, three inlet and three exhaust, and as will be clear from the cross-section given in Fig. 3, the motion of the sleeve can be and is made to open and close the inlet and exhaust ports as required. The form of the ports and their number was decided on after extensive experiments. It should be said that of the five ports in the sleeve two uncover inlet ports into the cylinder, two uncover exhaust ports and one opens an inlet and exhaust port alternately. It will be clear from Fig. 3 that the cylinder ports communicate very directly with the carburettor and exhaust pipe. The latter is arranged on the front of the engine so that the exhaust area obtains full benefit from the draught caused by the passage of the machine through the air. The carburettor is mounted directly on the inlet pipe as shown in Fig. 6. The shaft carrying the half-time wheel, to which reference has already been made carries on its outer end a pinion which can be seen in section in Fig. 5. This drives the magneto through an idle wheel as is best shown in Fig. 1. A detachable cover encloses the gear. The bracket carrying the magneto together with the timing gear may be withdrawn as a unit by taking out four set screws. This may be done without disturbing the magneto setting relative to the sleeve-valve.

The relation of the sleeve to the piston and cylinder is clearly shown in Figs. 2 and 5, but attention may be

SINGLE-CYLINDER AIR-COOLED SLEEVE-VALVE MOTOR-CYCLE ENGINE.

CONSTRUCTED BY MESSRS. BARR AND STROUD, LIMITED, ENGINEERS, GLASGOW.

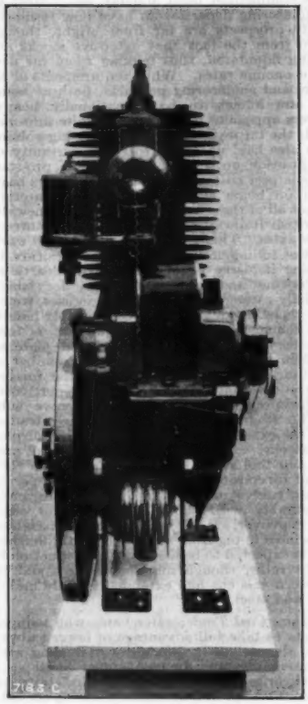


FIG. 6. INDUCTION SIDE OF ENGINE.

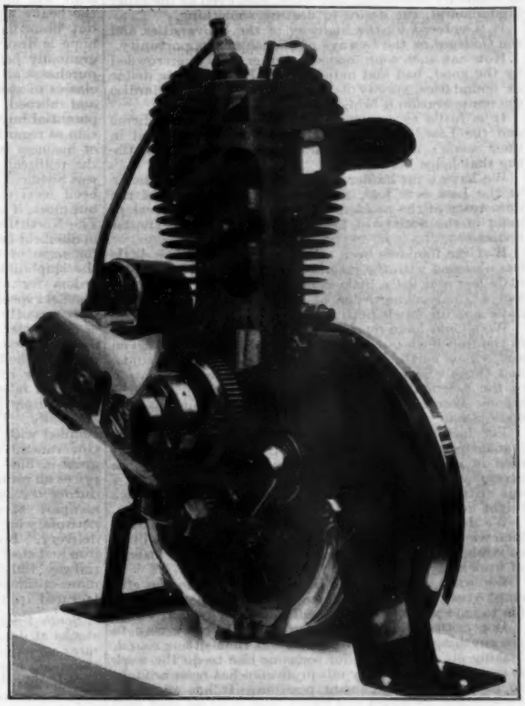


FIG. 7. ENGINE WITH SECTIONED CYLINDER SHOWING SLEEVE.

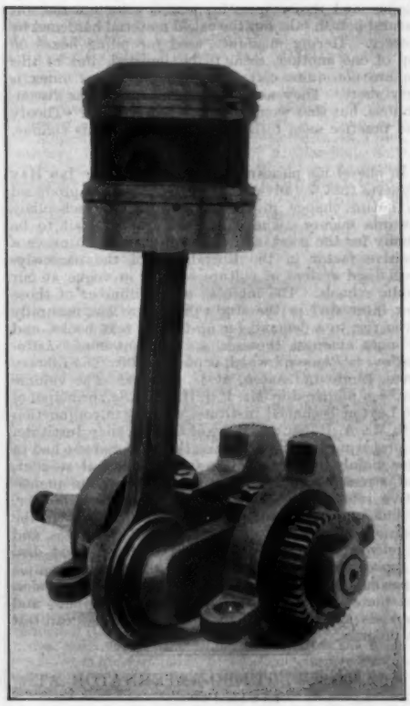


FIG. 8. PISTON AND CRANKSHAFT UNIT.

directed to the function of the piston ring carried by the cylinder head which has already been mentioned. As will be seen, this seals the upper side of the combustion space. The piston is of cast-iron and carries two rings at the top and a scraper ring in the skirt. The top of the piston is shaped to give a combustion space of good form. The lubrication of the engine is by splash. Oil is fed to a point in the cylinder near the lower end of the sleeve, and the motion of the latter distributes it over the entire contact surface inside and out. The bearings are lubricated by splash from the crank case. It is hardly necessary to say that the engine is beautifully made. The fact that it comes from Messrs. Barr and Stroud's works at Annisland, Glasgow, is sufficient guarantee for the best class of workmanship. We should perhaps add that the London office of the company is at 15, Victoria Street, Westminster.

NOTES ON NEW BOOKS.

AMERICA has given us some very good technical treatises on elementary mechanics, in which practical work is happily blended with theory. Departure from strictly classical lines, or should we say, established precedent, does not appear to weigh so heavily on the mathematical conscience with American teachers as with us, and greater disposition is shown to use mathematics as a tool for the accomplishment of definite ends, than a device for exhibiting elegant results after approved methods. Among recent arrivals may be mentioned with satisfaction, Professor Boyd's work on *Mechanics, a Text-Book for Engineers*, published by the McGraw-Hill Book Company, of New York and London. Price 21*s.* net. The work is intended to provide such an acquaintance with the principles of mechanics, that a student will be able to pursue intelligently the problems that will subsequently come before him connected with machine design, stresses in structures, and strength of materials. But it does more than that. It supplies such a general foundation, that in whatever direction the student may turn later, he will have the necessary equipment for mastering and profiting by the more elaborate works prepared on special topics. The work may be described as a preparatory treatise, designed for those who have read some elementary mathematics and wish to grasp the theory on which engineering science is built. Also, it is, as it should be, eminently practical, the exercises, of which there are a great number, are skilfully graduated, and illustrate problems that may actually occur. It is recommended that solutions be obtained by processes that are the most easily handled. It may be necessary to omit the effects of friction from the earlier problems, giving an air of unreality, but this is unavoidable. Some may take exception to the definition of force, or possibly what will be regarded as the absence of definition. The author describes force as capable of being perceived by the muscular sense, and we hold that he is justified, for it is of the effects of this recognizable force of which he is writing, and not some philosophical conception which is apprehended only after the general problems of mechanics have been studied and mastered. We imagine his pupils will be grateful for his reticence, and will think none the worse of their professor, because he is old-fashioned enough to quote Newton's three laws of motion, without attempting to modify the substance or to reduce the number. There is no great scope for originality of treatment in an elementary mathematical treatise. The materials exist in many places, and unconsciously these must be drawn upon; it is of more importance to note that each problem is followed through in a very satisfactory manner, and that the author spares no pains to secure lucidity. The style and scope of the book will be understood, if we say that vectorial notation is employed from the first, and the theory of couples is introduced as early as possible. The calculus is used very sparingly, and no great demand is made upon the student's acquaintance with pure mathematics, though we think the author would prefer him to have some acquaintance with hyperbolic functions. An excellent feature is the summary given at the end of each chapter to serve as an *aide-memoire*.

FIG. 9. THE SLEEVE-VALVE.

Not many years ago a professor writing on freight-handling machinery might have felt inclined to apologise for discoursing on so unscientific a subject, which might concern the store-foreman or the fourth officer on board more than the engineer. That there is a good deal of science in conveying and elevating machinery has, however, long been recognised generally, as well as by the manufacturer who may have made a fortune out of some efficient device, and these problems now claim the full attention of the designer of new works. The third edition of the "*Förderung von Massengütern*," vol. I, by Professor Georg von Hanffstengel [Berlin: Julius Springer, price in this country 234 marks] bears testimony to that fact. The first edition came out in 1908, the second was published in 1913. A literal translation of the title would be "Conveyance of Freight in Bulk," and this first volume deals with the construction of and calculation for continuously-operating machines. There is nothing superfluous in these 306 pages illustrated by 531 text figures. The matter is subdivided into three sections, power-driven machinery (Förderer mit Zugmittel), gravity machinery (ohne Zugmittel), and accessory appliances, shoots, lock gears for hoppers,

charging and discharging machines and weighing machines. Cranes are excluded, and we should have liked more information about this class of appliance. Among recent developments are noticed the American link-belts, which deliver a cask from one sectional link to another, the link drives being coupled by short chains; and the scrapers for potash salts, not the soft natural potash salt, but the caked material hardened by storage. Tiering machines, used for piling boxes on top of one another, seem to be omitted, but of this we are not quite certain; the alphabetical index is very short. They may have been omitted as discontinuous, but that would likewise bar hoppers. Theory and practice seem to be well combined in this volume.

In one of his pleasant stories of school life Ian Hay observes that the advent of the motor car had produced an entire change in the attitude of the schoolboy towards science. The change can hardly fail to be wholly for the good, and may be expected to prove a decisive factor in the liberalising of the narrowly-specialised system of culture so long in vogue at our public schools. The increase in the number of those now interested in the study of Nature has naturally given rise to a demand for up-to-date text books, and we note amongst these is an excellent one, "*Introductions to Physics*," which is published by The Library Press, Limited, London, at 4*s.* 6*d.* net. The volume has been prepared by Mr. P. J. Haler, B.Sc., principal of the Leyton Technical Institute, working in conjunction with Mr. A. H. Stuart, B.Sc.,of the Hackney Institute. In preparing this little treatise the authors have had in view mainly the needs of the junior technical student, and stress has accordingly been laid on the quantitative relationships between the properties of matter. Included in the subject-matter are chapters on the distinctive properties of solids, liquids and gases, and the elements of sound, light and heat. A good deal of space is devoted to the description of simple experiments in these different branches of physics, and there are numerous worked out examples, and exercises are also given by which the reader can test his progress.

"12,500 KW. TURBO-ALTERNATOR AT LIVERPOOL."

TO THE EDITOR OF ENGINEERING.

SIR,—In ENGINEERING, December 30, 1921, there is a description of the new 12,500-kw. turbine for the Liverpool Corporation.

At the bottom of page 873 the turbine is said to consist of one velocity compounded wheel, and 10 Rateau wheels. Is this correct? The statement which I question is the velocity compounded wheel, for the reasons given below.

Comparing this turbine with one of the M-V sets at Dalmarnock, I could not see the necessity for velocity compounding the first wheel.

The mean blade speed is the same in the Liverpool machine as in the Dalmarnock machine; the total heat drop at Dalmarnock is 253 lb. calories, and there are 14 stages making the average heat drop per stage 18·06 lb. calories; at Liverpool the heat-drop is 199 lb. calories, and there are 12 stages giving an average heat drop of 16·3 lb. calories per stage, which can, of course, be used with Rateau wheels.

Another point, which makes me doubt the statement, is that the nozzles of the first stage do not seem to be intended for a velocity compounded wheel with a blade speed of 550 ft. per second, as the steam velocity would not be sufficient unless the expansion was continued considerably below the critical pressure.

I am aware that the sectional arrangement shows a velocity compounded wheel, but the photograph of the rotor on page 876 looks as if the second row of blades was not fitted to the first wheel, and the T-slot does not seem to be there either.

The turbine appears to me to have been designed for modern high-pressure steam conditions, but with the low-pressure steam available at Liverpool the standard machine was used, but with the Curtis wheel converted into a Rateau wheel, by removing the second row of blades and the fixed blades.

I should be obliged if you would correct me if I am wrong.

Yours faithfully,

R. C. MCLEOD.

46, All Saints-road, Peterborough, January 1, 1922.

[We are informed by the makers of the turbine that as actually installed at Liverpoo' there is but one row of blades on the first wheel, as our correspondent surmises. The plans were, however, got out with a view to a contemplated increase in the boiler pressure at the power station, and when this change is made the present wheel will be replaced by a velocity compounded wheel with two rows of blades, as shown in the general arrangement reproduced in Plate XLVI of our issue of December 30.—ED.E.]

ENGINEERING AS A PROFESSION.

TO THE EDITOR OF ENGINEERING.

Sir,—There is nothing the matter with engineering as a profession, but there has been, is, and always will be a good deal the matter with engineering as a livelihood, simply because of its excellence as a profession.

It takes man everywhere, from crowded cities to the far ends of the earth; it has a place for the mathematician and for the craftsman; for the plodder and for him who seeks excitement; for those with technical administrative or executive abilities; it is interesting all along the line, first, last, and all the time. It appeals to the fundamental trait in human nature, the desire to construct something, and sometimes even to the other fundamental, the desire to destroy something.

It is entered by the highway of the Universities and the Colleges or the byways of chance and opportunity.

How can such a profession be other than overcrowded by the good, bad and indifferent? How can one define its boundaries, specify its requirements and standardise the remuneration it brings?

It is futile to compare our profession with medicine and the Law, which appeal to few and are limited in their scope; as well compare the latest liner with the tug that helps her to berth.

We have a far harder problem to solve than medicine or the Law ever had, and it is the recognition of the immensity of the problem that has delayed the development of the Society of Technical Engineers and similar bodies.

Had the founders been a little less intelligent, a little less obsessed with the magnitude of the task, dreamed a little less and led a little more, been a little bolder and had a greater knowledge of human nature, we should have got on much better.

We should have retained most of those who joined us in the first flush of enthusiasm, expecting a new Heaven and a new earth, because they had paid three pounds, and those who joined later with a greater appreciation of the position, but still expecting something for their money besides vague theories, wordy platitudes and endless hair splitting.

The fact that the Society still exists in spite of bad management and bad finance and counts many earnest men in good positions among its members, proves its necessity and augurs well for its ultimate success, and if our critics would join us to help push things along we might hope to accelerate the wheels of progress.

We do not want the hot head or the crank, we want men who, having achieved success themselves, are willing to strengthen the ladder by which they climbed instead of knocking it down as so many do.

We want the heads of the profession, who are still employees, to lead wisely, and we want the rank and file to lend weight to their leadership.

Our critics should remember that the only way to get anything is by striving for it, and that sitting round, looking on and waiting for someone else to do the work is certainly not the way our profession has been brought to its present predominant position. It has advanced by sacrifice, by blood and sweat, and until we staff men are willing to make sacrifices and to work, so long will staff societies languish and be ineffective for lack of men and money, and so long will the grumbler and the malcontent create disaffection where little cause exists.

We tried to tackle the question of remuneration which crops up in nearly every letter, but we found our sources of information were too limited; we need men from a large number of works in numerous industries, from the chief engineer to the latest recruit from college or technical school before we can attempt to say what is, or is not, a fair remuneration for a specific billet.

Employers are, for the most part, keen business men, they buy staff labour just as they buy everything else, and they buy to what they deem to be the best advantage; few of them sweat deliberately, and it is ridiculous for staff men to wail at being underpaid when they will do little or nothing to organise, to establish a standard, and to convince the employer that to buy cheap is not to buy well.

After all, it is not so much that vague entity sometimes called "Capital," and sometimes the "employer" who is to blame for low salaries as the chief employee who advises Capital, and if we had numbers fully organised, we would experience little difficulty in dealing with him in a just cause.

Yours faithfully,

J. ANDERSON,
Member of Birmingham Branch Council, Society of Technical Engineers. Chief Engineer to Geo. Ellison, Birmingham.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A meeting of this Institution is announced to be held in the South-Western District, Plymouth, on Friday and Saturday, the 20th and 21st inst., when institution and district business will be dealt with. There are to be also the reading and discussion of a paper, and visits to works of interest.

CONTRACTS.—Messrs. Boving and Co., Limited, 56, Kingsway, W.C.2, state that they have recently been awarded a contract by the Government of New Zealand for water turbines in connection with their Mangahac hydro-electric power scheme. This order includes five main Pelton wheels, three—each having a maximum output of over 8,000 brake horse-power, and two—each over 4,000 brake horse-power; also two smaller exciter Peltons each of 325 brake horse-power; these machines will thus have a total capacity of nearly 33,000 brake horse-power. The water wheels will work under an average head of 825 ft.—The Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has booked through its Japanese agents, Messrs. Takata and Co., for the Daido Electric Power Company, Japan, a contract for 34 transformers, averaging 9,400 k.v.a. each, a total of 316,400 k.v.a. The transformers will be single phase, 60-cycle, oil insulated and water-cooled, and will have a voltage of 154,000, the highest voltage in commercial use at the present time. When installed, they will weigh 50 tons each.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The Christmas stoppage in all departments proved longer than was expected. Owing to the dearth of new business, production on a considerable scale was not commenced until Monday last. Most of the heavy engineering departments have now resumed, but immediate prospects are far from bright, though hope is drawn from the fact that extensive stocks are gradually being liquidated, thus making room for new purchases at economic rates. While requirements of all classes of steel and engineering products, both at home and abroad, are known to be exceptionally heavy, potential buyers appear to be awaiting definite information as regards the future trend of prices. A big volume of business is also held up owing to the uncertainty of the political position on the Continent, which, pre-war, was Sheffield's largest customer. A few new orders have been received on home account for railway material, but most, if not all of these are in the nature of renewals. The North British Railway has placed a minor contract in Sheffield for axles. This is finding much needed work for some of the rolling mills. The serious position in the shipbuilding industry is reflected in the dearth of orders for shafting and turbine forgings, for which Sheffield specially caters. The big steel foundries, which have recently been remodelled, could comfortably handle a far bigger tonnage. A satisfactory feature is that despite keen competition from Belgian and German makers, Sheffield continues to receive a fair number of orders for rolling-stock for export, and if the further expected falls in raw materials, fuel and transport costs materialise, prospects are expected to improve substantially. The stagnation in the engineering trades, coupled with the existence of vast quantities of surplus Government stocks, continues to militate against progress in files and tool steels. The hopeful side is that prices all round are considerably lower than at any period during the last twelve months, and in most instances compare favourably with those of Continental competitors, who, moreover, are not in a position to guarantee delivery. Business in pig-iron, scrap and partly-finished iron and steel is expected to benefit from the reduction in railway freight rates, though manufacturers would be more optimistic if this cut had extended to fully manufactured iron and steel.

South Yorkshire Coal Trade.—Merchants who reduced stocks at depots to take full advantage of lower railway rates now find themselves in difficulties in dealing with the much improved demand for best-quality house coal. Day-to-day deliveries from the pits are easily absorbed. The improvement is expected to continue during the cold weather. Second qualities are in fair demand, but consumers show diffidence in accepting deliveries of unscreened sorts at cheap rates. The home industrial demand is rather more active now that engineering and steel works are resuming operations. Inquiries for export are more numerous, with prices firm. Gas and electricity concerns are buying more cautiously now that the holiday rush has been met. Smalls and coke dull. Quotations: Best branch handpicked, 39*s.* to 40*s.*; Barnsley best Silkstone, 38*s.* to 40*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 27*s.* to 28*s.*; Yorkshire hards 29*s.* to 30*s.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 15*s.* to 16*s.*; smalls, 5*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As was anticipated, Cleveland pig-iron prices have been officially further reduced, and as was also expected the fall has brought customers into the market. No. 1 and No. 3 G.M.B. are each down 10*s.*, and the lower qualities have been lowered by 7*s.* 6*d.* Thus No. 1 becomes 95*s.*, No. 3 90*s.*, No. 4 foundry 87*s.* 6*d.*, and white 82*s.* 6*d.* There is an open market for mottled, and white iron. Steady expansion of transactions is now looked for, traders arguing that quotations have fallen to levels which admit of successful competition with foreign producers.

Hematite.—There is not much new to report concerning East Coast hematite. Prices are rather easier in sympathy with the fall in Cleveland pig-iron, but there is quite a good business passing, the cheapness of the product of this district, as compared with rates ruling for other hematite irons, having attracted custom over a large area at home, and from several Continental consumers. Both for home purposes and for shipment abroad, Nos. 1, 2 and 3 are in the neighbourhood of 100*s.*, though sales are reported to have been made at 97*s.* 6*d.* No. 1 is half-a-crown above mixed Nos.

Average Price of Pig-Iron.—The average net selling price of No. 3 Cleveland pig-iron for the months of October, November and December, 1921, has been certified at 111*s.* 2·15*d.* per ton, as compared with 131*s.* 5·13*d.* per ton for the previous quarter. There was thus a reduction in the last quarter of the year of 20*s.* 2·98*d.* per ton. The latest ascertainment does not effect blast-furnacemen's wages, a special arrangement having been made between the Cleveland ironmasters and the blast-furnacemen's representatives, whereby the district percentage is reduced from 77½ to 36.

Wages and Hours of Ironstone Miners.—Under sliding-scale arrangements a reduction of 25·3 per cent. is due in Cleveland ironstone miners' wages, lowering wages from 129·3 per cent. to 103·9 per cent. above the base rate. The mineowners this week intimated their desire of a lengthening of working hours, both of underground and

surface workers. At present, in the mines a 7-hour day is in operation, and as this includes the time occupied in getting in and out, the total amount of time spent in the mine averages very considerably less per day. It has been agreed to postpone the question for three months, the employers intimating that they will then bring forward a proposal for the establishment of an 8-hour day for the miners, and a 49-hours' week for surface workers, as against 46½ hours now worked by the latter. As an alternative they will press for a reduction in wages equivalent to the payment for the extra hours which they desire the men to work.

Foreign Ore.—There is more doing in foreign ore, but as yet business is not on an extensive scale. Best rubio may be quoted 26*s.* 6*d.* c.i.f., though it is reported that as low as 26*s.* has been accepted.

Coke.—Blast-furnace coke is decidedly easier, but sellers continue to ask more than local consumers are prepared to pay. Average blast-furnace Durham's may now be quoted 27*s.* delivered.

Manufactured Iron and Steel.—Little new is ascertainable just now concerning finished iron and steel. Orders are very scarce and prices are weak. To home customers common iron bars are 12*l.* 10*s.*; iron rivets, 14*l.* 10*s.*; soft steel billets, 7*l.* 10*s.*; medium steel billets, 9*l.*; hard steel billets, 9*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 13*l.* 10*s.*; and corrugated galvanised sheets, 17*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The depression which has been all too prevalent in the steel trade of Scotland during recent months has not yet shown signs of lifting, with the result that the New Year holidays are of an extended duration this year. Few of the works have commenced operations yet, and it will be next week before a general resumption takes place, and even then some may not commence. It was thought that buyers might have been inclined to re-enter the market now and give out some tolerably respectable specifications, but so far there has been little of that, and bookings during the holiday season have not amounted to a heavy tonnage. The consequence is that few of the works have much business to start up with, and so the outlook is not very bright. There is little demand from the shipbuilding yards for either plates or sections, and makers are cutting very keenly to secure any lines on offer. Orders for boiler plates are very poor, also, but there is a shade more business of a general character passing in structural material. Black sheet makers complain of a scarcity of orders, and work on hand does not assure regular running of plant beyond a very limited period. Inquiries from abroad are better, but it is the turning of these into actual business which is the difficulty. This week export prices may be taken as 15*s.* per ton cheaper with black sheets, ⅛ in. and ¼ in., called 10*l.* 15*s.* per ton, and 11*l.* per ton, f.o.b., Glasgow. The general export trade is a very negative quantity at the present time. Prices for the home market are the turn easier.

Malleable Iron Trade.—The malleable iron trade in the West of Scotland has not yet got into swing, but next week should see the majority of the works in operation. Up to date there has been little fresh business booked, and hand-to-mouth conditions are very probable for a bit. Prices are unchanged, with "crown" bars called 12*l.* 10*s.* per ton delivered Glasgow.

Scottish Pig-Iron Trade.—There has been little movement in the Scottish pig-iron trade this week, and the only item of note is that prices are the turn softer. The steel works not having restarted there has been little demand for hematite iron, but there is a feeling that foundry sorts will be more active shortly. At present the stocks are ample to meet a fairly large call, and extra furnaces will not be relighted until absolutely necessary. Export trade is still very quiet.

Scottish Shipbuilding.—Few of the shipbuilding yards made a decent start this week, and on the other hand few of them have a great deal to start to. The approximate amount of work under construction in the different areas may be summarised as follows:—

		January, 1922.		January, 1921.	
		Vessels.	Tons.	Vessels.	Tons.
The Clyde	Steam	140	825,239	227	1,154,127
	Motor	20	133,485	22	147,745
	Sail ..	3	990	16	3,316
The Forth	Steam	6	21,870	23	52,893
	Motor	—	—	1	3,845
The Tay	Steam	17	57,300	23	64,790
	Motor	1	7,700	2	600
The Dee and Moray Firth	Steam	6	7,795	16	16,340
	Motor	—	—	1	450
Totals		193	1,054,379	331	1,444,106

PERSONAL.—Mr. W. Rutherford, formerly managing director of Messrs. Dick Kerr and Co., Limited, and subsequently of the English Electric Company, Limited, has been elected a director of G. D. Peters and Co., Limited, 3A, Dean's Yard, Westminster, S.W. 1. The name of the sole agent for Scotland of Messrs. Hollings and Guest, Ltd., was wrongly spelt under this heading, on page 23 *ante*; it should read D. Landale Frew.

NOTICES OF MEETINGS.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Monday, January 16, at 7.30 p.m., at the Y.M.C.A., Albion-place, Leeds, when Sir Henry Fowler, K.B.E., will read his paper on "Steel for Locomotive Purposes." The chair will be taken by Mr. A. C. Stamer.

THE INSTITUTE OF MARINE ENGINEERS, INCORPORATED.—Tuesday, January 17, at 6.30 p.m., "Weather at Sea, including Clouds, Waves, &c.," by Sir D. Wilson-Barker. Lantern views. Ladies' night.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Tuesday, January 17, at 7 p.m., at the Metropole, King-street, Leeds. Paper by Dr. S. P. Smith, Member, on "Single and Three-Phase Alternating Current Commutator Motors with Series and Shunt Characteristics."

THE INSTITUTE OF METALS, BIRMINGHAM LOCAL SECTION.—Tuesday, January 17, at 7.30 p.m., in the Chamber of Commerce, New-street, Birmingham. Paper by Professor C. A. Edwards, D.Sc., on "The Influence of Time and Temperature on the Properties of Alloys."

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, January 18, at 2.30 p.m., in the Mappin Hall, Applied Science Department, the University, St. George's-square, Sheffield. A general discussion will take place on "The Durability of Glass," and the following papers will be presented in this connection: (*a*) "An Examination and Extension of Zulkowski's Theory of the Relation between the Composition and Durability of Glasses," by Mr. W. L. Baillie, A.I.C.; (*b*) "A Critical Note on the Methods of Determining the Durability of Glass," by Mr. W. E. S. Turner, D.Sc.; (*c*) "The Action of various Reagents on the Surface of Chemical Glassware," by Mr. W. E. S. Turner, D.Sc., and Mr. T. E. Wilson, B.Sc.; (*d*) "The Effect of Magnesia on the Durability of Glass," by Miss C. M. M. Muirhead, B.Sc., and Mr. W. E. S. Turner, D.Sc. Further contributions to the discussion are invited.

THE NORTHAMPTON ENGINEERING COLLEGE, ENGINEERING SOCIETY.—Wednesday, January 18, at 5.30 p.m., Film on "Electricity in Steel Works" (B T H). At 6.30 p.m., Discussion on "Appointments," with past students.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Wednesday, January 18, at 7 p.m., at the Hall of the Institute of Chartered Patent Agents, Staple Inn Buildings, Holborn, W.C., when Mr. H. W. Allingham, M.I.Mech.E., M.A.S.M.E., will open a discussion on "Methods of Remunerating Labour."

THE BRADFORD ENGINEERING SOCIETY.—Wednesday, January 18, at 7.30 p.m., in the Hall of the Technical College. Lecture by Mr. R. Allan, A.M.I.Mech.E. (of Luton), on "Ball Bearings," illustrated by lantern slides and the cinematograph.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, January 18, at 7.30 p.m., 49, Cromwell-road, South Kensington. Annual General Meeting; Presentation of the Symons Medal, awarded to Colonel H. G. Lyons, D.Sc., F.R.S.: Address on "The Weather and the Crops in Eastern England, 1885–1921," by Mr. R. H. Hooker, M.A., F.S.S., President.

THE ROYAL SOCIETY OF ARTS.—Wednesday, January 18, at 8 p.m., "Recent Advances in the Determination of Sex in Animals," by Mr. Julian S. Huxley, M.A., Fellow of New College, Oxford. Mr. Peter Chalmers Mitchell, C.B.E., M.A., LL.D., F.R.S., F.L.S., F.Z.S., Secretary of the Zoological Society of London, will preside.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, January 19, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. A paper on "Aeroplane Installation" will be read by Brigadier-General R. K. Bagnall-Wild, C.M.G., C.B.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 19, at 6 p.m., Joint Meeting with the Institution of Heating and Ventilating Engineers. Discussion on "The Utilisation of Waste Heat from Electrical Generating Stations," with the following introductory papers; "Utilisation of Exhaust Steam from Electric Generating Stations and Coal Economy," by Mr. C. Ingham Haden, and "The Utilisation of Waste Heat from Electrical Generating Stations," by Mr. F. H. Whysall.

THE INSTITUTION OF CIVIL ENGINEERS, BIRMINGHAM DISTRICT; THE INSTITUTION OF MECHANICAL ENGINEERS, MIDLAND DISTRICT; THE INSTITUTION OF ELECTRICAL ENGINEERS, SOUTH MIDLAND DISTRICT.—Friday, January 20.—A Joint discussion will be held at the Council House, Birmingham. Subject, "The Electrification of Main Line Railways." The chair will be taken at 7 p.m. by Sir Henry Fowler, K.B.E., M.Inst.C.E. Speakers: Mr. Wm. Willox, Mr. C. E. Bengough, M.M.Inst.C.E.; Mr. H. M. Gresley, Mr. J. A. Hookham, M.M.Inst.M.E.; Mr. R. T. Smith, M.I.E.E., Mr. F. W. Carter, M.A., M.I.E.E.

THE INSTITUTE OF METALS, SHEFFIELD LOCAL SECTION.—Friday, January 20, at 7.30 p.m., in the Mappin Hall of the University of Sheffield, St. George's-square, a paper by Mr. F. C. Robinson and Mr. H. G. Dale, on "An Investigation of Some Defects in Silver-Plating Anodes."

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: MERSEYSIDE BRANCH.—Friday, January 20, commencing at 7.30 p.m., in the Walker Engineering Building, the University of Liverpool. A Lecture entitled "The Tides," will be given by Professor J. Prowdman, M.A., D.Sc. (the University of Liverpool).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 20, at 8 p.m., at Caxton Hall, Lecturette, "Geology in its Relation to Engineering."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 20, at 6 p.m., "Some Observations on a Producer-Gas Power Plant," by Mr. H. S. Denny, C.B.E., and N. V. S. Knibbs, B.Sc. A meeting of the Graduates will be held at the Institution, Storey's Gate, on Monday, January 23, 1922, at 7 p.m. Paper, "Airships," by Mr. F. Arnold Best, of Sheffield, Graduate. Chairman, Air Vice-Marshal P. W. Game, C.B., D.S.O.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 20, at 9 p.m., a discourse will be delivered by Sir James Dewar, LL.D., D.Sc., F.R.S., Fullerian Professor of Chemistry. The subject is "Soap Films and Molecular Forces." Afternoon Lectures, at 3 p.m.: Tuesday, January 17, Mr. F. H. A. Marshall, Sc.D., F.R.S., on "Physiology as Applied to Agriculture (Lecture 1); Thursday, January 19, Mr. Seton Gordon, F.Z.S., on "(1) Mountain Birds of Scotland"; Saturday, January 21, Mr. Charles Macpherson, Mus.Doc. professor R.A.M., St. Paul's Cathedral, Pres. Roy. Coll. of Organists, on "The Evolution of Organ Music" (with musical illustrations) (Lecture 1).

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—New business in the coal trade is restricted, and buyers, where practicable, are proceeding on hand-to-mouth lines. Generally prices are irregular and dependent on the individual circumstances of buyer and seller. A large quantity of shipping, which was delayed by the recent bad weather, has arrived during the past few days, and this has placed some collieries in a comfortable position. On the other hand, the available loading facilities are unable to expeditiously cope with the tonnage in dock, and this has resulted in delay in the return of wagons to the pits. Thus in many instances collieries are in the vexatious position of having shipping in dock waiting for cargoes, and trucks held up at the docks and the regular working of pits imperilled. The dock companies have suggested that instead of the coal tippers and trimmers working in two continuous day shifts of 8 hours each a split shift should be re-introduced of 9 hours each, with an hour's break for meals, one shift by day and one by night. It is contended that this would result in the docks being able to deal with 20 per cent. more coal than is the case at present. It now remains to be seen whether the men will agree to the change. The general opinion is that while the change would be beneficial to the trade many are dubious as to whether the men will be willing to work by night, as the men contend that given adequate facilities they can ship the whole of the coal during the day. At present best Admiralty large coal is from 24*s.* 6*d.* to 25*s.*, seconds 24*s.* to 24*s.* 6*d.*, best dry large 24*s.* to 24*s.* 6*d.*, ordinary dry 23*s.* 6*d.* to 24*s.*, and the leading Monmouthshires from 22*s.* 6*d.* to 23*s.* 6*d.* The better quality steam smalls are scarce, and taken in conjunction with large, from 16*s.* to 17*s.* 6*d.*, but by themselves command a premium of 1*s.* Cargo smalls are in ample supply round 13*s.* 6*d.*, and dry smalls from 11*s.* to 12*s.* 6*d.* Exports of coal as cargo, foreign from South Wales in 1921, totalled 12,017,510 tons, compared with 14,398,760 tons in 1920 and nearly 30,000,000 tons in 1913. Of last year's shipments 3,976,046 tons were supplied to France, 2,080,592 tons to Italy, 1,128,336 tons to South America and 1,245,792 tons to British coaling stations.

Resumption of Iron Ore Imports.—It is twelve months ago since iron ore was imported into Cardiff, which port did a large trade in this mineral, for in 1920, 715,807 tons were landed. In 1921, however, only 28,000 tons were brought to the port. The importation of this mineral is being resumed, for Messrs. Guest, Keen and Nettlefolds, Limited, have four cargoes totalling 15,200 tons on their way to the port, three from Bilbao and one from the Mediterranean.

THE LOSS OF THE AIRSHIP R. 38.—A short report issued by the Secretary of the Admiralty, on Tuesday last, deals with the design of the R. 38 and the early stages of her construction up to the autumn of 1919, when responsibility was transferred to the Air Ministry. The report states that no undue risk was taken in the design, and that as regards safety, no change from previous practice was made which was not justified by experience or by comparison with German ships. No modifications affecting the structural strength of the vessel were made while the Admiralty was responsible for her, although additions were made in weight, and no important alterations in the design were made after she was handed over to the Air Ministry. Such alterations as were subsequently made to the fins, cars and other parts as a result of experimental investigations and in order to economise weight, would not, it is stated, affect the strength of the structure. With regard to the suggestion made at the court of inquiry, and referred to on page 545 of our last volume, that the design of the airship should have been discussed by a committee of experts before construction was commenced, it is pointed out that no such body was in existence at the time, and that it would not have been possible to call one together since practically all the expert opinion of the country was already engaged on the work. This report certainly throws no light on the real cause of the disaster, but doubtless this will be forthcoming from the report of the Aeronautical Research Committee, who are also investigating the matter, and whose labours should now be approaching completion.

STEAM AND ELECTRIC LOCOMOTIVES FOR THE NORTH-EASTERN RAILWAY.

CONSTRUCTED TO THE DESIGNS OF SIR VINCENT L. RAVEN, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page* 39.)

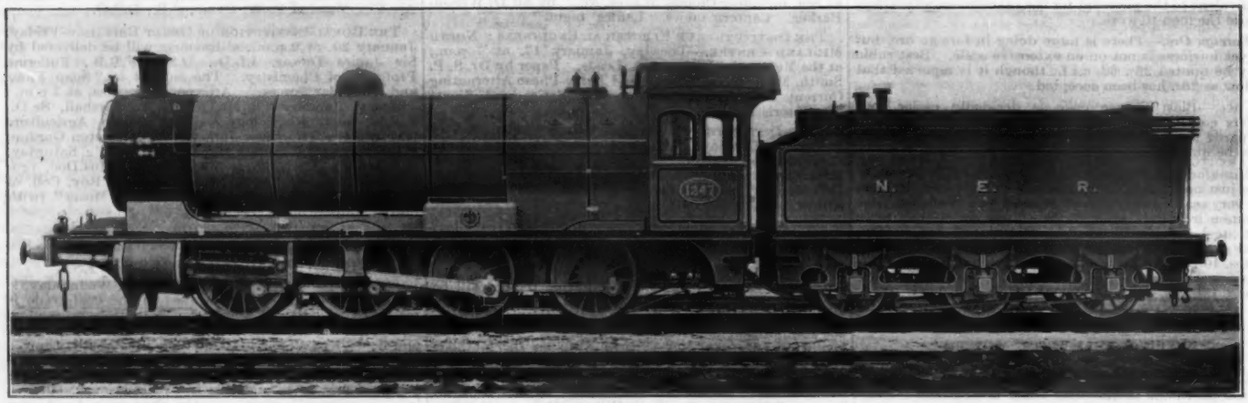


FIG. 11. 0-8-0 TYPE STEAM FREIGHT LOCOMOTIVE.

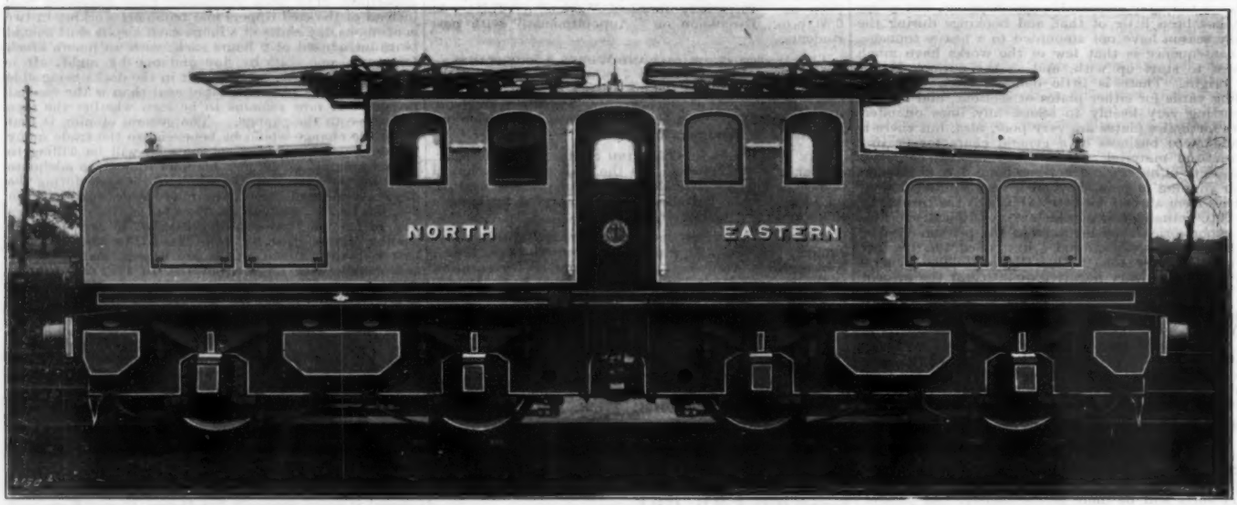


FIG. 12. 0-4'+4-0 TYPE ELECTRIC FREIGHT LOCOMOTIVE.

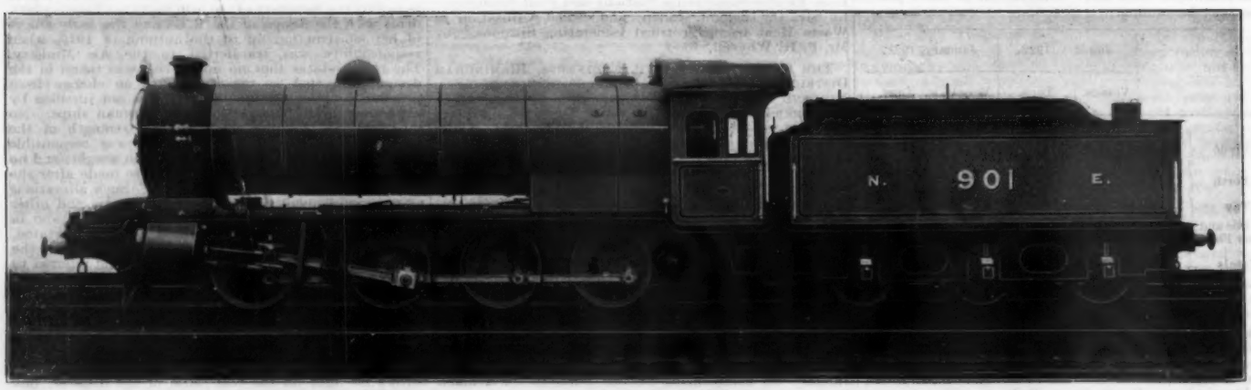


FIG. 13. 0-8-0 TYPE STEAM FREIGHT LOCOMOTIVE OF LATEST CLASS.

ENGINEERING.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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Thin paper copies	£3	3	0
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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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1,500-*VOLT DIRECT-CURRENT ELECTRIC FREIGHT LOCOMOTIVE* (0-4 + 4-0 *TYPE*) *FOR THE NORTH-EASTERN RAILWAY.*

ENGINEERING.

FRIDAY, JANUARY 13, 1922.

GREATER LONDON.

THERE would appear to be an idea abroad that one of the outcomes of the Royal Commission, which is now inquiring into the local government of London, will necessarily be an increase in the size of the area administered by the County Council. In many quarters this appears to be taken as an axiom, and with that axiom goes the postulate that size breeds efficiency. The notion of the necessary value of combination and enlargement is of somewhat old standing, but it received an impetus and new inspiration from the "golden age" which followed the armistice, or rather from the golden age to which the years following the armistice were to lead. An elementary calculation would appear to show that chronologically we have now reached that golden age, but we have failed to perceive any extreme manifestations of public joy from its incidence, and it is not only those lacking a Celtic imagination who are beginning to doubt if the inaugural steps were all for the best. Our golden age was to be established, in the main, by extensions of official control in all sorts of directions and the general bringing together of independent activities under common administration. Our pitiful attempts at flight to the promised land of bliss have, however, suggested to quite a number of people that perhaps after all our new equipment was not altogether what was required.

It would be both unfair and absurd to suggest that our present discontents are to be laid solely at the door of the crop of bureaucratic inspirations which followed the war, but it would be neither unfair nor absurd to suggest that three years trial proves very clearly that in the present financial condition of this country and of the world there is neither time nor money available for ambitious administrative experiments. Theoretically, and for purposes of argument, large combinations, either public or private, make for efficiency and cheapness. In practice, in nine cases out of ten, they make for neither. This, however, is never admitted by the combiner and nationaliser. Ignoring all experience, he is at any time prepared to point out the economies which a large authority or body can practice compared with a small. He at the present time is ready to prove that the dweller in one of the outer suburbs will benefit if his area is taken into the County of London, although all experience shows that the dweller will simply pay higher rates and get little or nothing more for them.

In connection with this Royal Commission, the London County Council has brought forward an ambitious programme for extending its sphere far out into the country districts in all directions, and it may be taken as certain that practically every district affected will protect against inclusion. To some extent this protest will arise owing to a feared loss of some authority on the part of district councils and similar bodies, but in the main it will arise owing to a fear of higher rates. Experience in the provinces in general justifies this fear and the taking of rural districts into towns has usually resulted in a rise in rates. The case of the London County area is hardly a parallel one, however, and it is not possible to make a case that high rates necessarily follow County Council jurisdiction. There are certainly 21 boroughs in the county area with rates of 14*s.* or over and only eight (including the City of London) with rates below 14*s.*, but most of the heavily rated areas contain a large working-class population. Similar conditions outside the county area give similar results, and there are eight boroughs or urban districts with rates of 14*s.* or over in Essex, two in Hertfordshire, four in Kent, sixteen in Middlesex and two in Surrey.

Another argument which is used for the inclusion of outer areas in the county is that they are in essence parts of the county; they draw their prosperity from it and are in many cases but dormitories in which the workers in London sleep. In the case of provincial towns a similar state of affairs is sometimes used as an argument not only for taking over such outer districts, but for equalising rates over the whole extended area. This argument cannot be used in its elementary form in connection with the county of London, since the County Council is not the main rating authority, but the implication underlying it is used as an argument. This implication we believe to be unfair. A dweller in an outer district does not obtain the same advantage from the expenditure of a public authority as does a dweller nearer at hand. The expenditure of the London County Council does not benefit the inhabitant of Epsom in the way it benefits the inhabitant of Hammersmith.

It is mainly, however, on the score that it is but another of the inflated schemes of unification and combination, of which the country has had more than enough, that the London County Council extension of area scheme may be opposed. The carrying through of schemes of this kind does not save money, it costs money, both initially and permanently. Any technical or directing staff which may be saved by taking in new areas is always entirely outbalanced by the increases which necessarily follow in clerical staffs. One may reasonably inquire what advantage will accrue to the public if this extensive extension is carried through, and in this connection some enlightenment might be expected from Mr. W. R. Davidge, who read a paper on "The Problems of Greater London" before the Surveyors' Institution, on the 9th inst. As is clear from his paper, Mr. Davidge is a supporter of the extension scheme.

The first point dealt with in detail by Mr. Davidge is that of traffic congestion and suburban travel. He is of opinion that "the whole of our transit system in Greater London requires to be overhauled and improved. An entirely new plan is necessary. We want new railways, new express tube services, street widenings, quicker trams and non-stop omnibuses." Academically one may agree with all this, but financially in 1922 the prospects do not appear too rosy. One of Mr. Davidge's schemes is "express" tubes driven under our existing tubes and "great extensions" in "all directions." He raises the question as to who is to finance these things, and states that "the public must have some say in a matter which so vitally affects their interests." We think he need have no fear but that the public will have plenty to say about these projects if they are undertaken by an enlarged London County Council in any near future. All scheming of this kind is but an example of the sort of thing of which we have had more than enough since the war. Our present business is to make our existing railways pay; when we have reached

that stage we may talk about "great extensions." The relation of these matters to the London County Council lies in the fact that it is proposed that the extended body shall have control over all forms of transport and Mr. Davidge says that in these conditions it must not run trams. With his latter opinion we entirely agree. The necessity for a traffic authority for Greater London has long been a subject of discussion, and if the London County Council were to come forward with a proposal to the effect that it should assume such duties, and at the same time should cease to be a traffic-operating authority, it would receive a large measure of support. The matter would, however, certainly not be a simple one. The London tramway system represents an enormous amount of public money which must be conserved as far as possible, and the Council might not easily find a purchaser to take it over on the financial basis they would desire. None the less, if the Council is to become the traffic authority for Greater London it must be done, and it would help Mr. Davidge's case for extension of the county boundaries if there had at any time been a shadow of a suggestion that the Council proposed to give up their trams.

This question of transport and a single authority over a large area dealing with roads and railways is really Mr. Davidge's strongest argument for extension, and if it is to break down over the trams he has not a great deal left. We do not gather that he proposes the enlarged Council should take over water supply, and we certainly see no advantage in transferring the authority of the Metropolitan Water Board to the Council. In the matter of electricity supply we note however that the "scheme for a joint electricity authority . . . will no doubt materialise under the ægis of the new 'central authority'." This is surely worse even than the trams. Admittedly "the ægis of the new central authority" is not a very definite phrase, but it means, if it means anything, that the London County Council are to run the new joint authority. In view of the argument and discussion which have already gone to this question, and the measure of agreement which has already been secured between the London County Council and other bodies, one may at least suggest that it seems somewhat undesirable to bring forward some quite new proposal at this date. It is going to be difficult enough to get agreement on present lines without the matter being complicated by new London County Council proposals. The Council has, with singular unsuccess, already made more than one attempt to become the electricity authority.

If the arguments for an extension of the County of London have no more practical validity than those relating to transport and electricity supply, it would appear that things may as well remain as they are. Mr. Davidge certainly makes a somewhat better case for sewage disposal, but it does not appear that his proposed extended authority is to do anything any different from what is being done, while in the matters of fire prevention and refuse removal he evidently does not expect much from centralisation. Education is another matter dealt with which is too large a subject for us to enter into at the end of an article. Something may be said for centralisation here, but not enough to cause us to alter our opinion that the proposed extension of London is merely another of the sweeping schemes which have been brought forward in all sorts of directions since the latter days of the war, with very little consideration of the detail work they will involve and the difficulties they will raise. The present business of this country is to get its activities and industries on to an economic basis. Dreams of the future may profitably be left to the future.

THE MODEL ENGINEER EXHIBITION.

THERE is something about models, and especially models of an engineering nature, which makes an extraordinary appeal to the mind of the average person. A hundred people would pause to gaze at the model of a locomotive for every one who would bestow a glance on its full-sized prototype, and many more would shew an interest in a model of the Forth Bridge than would even look up from their paper when passing across the structure itself. Although there are several firms who devote themselves specially to the manufacture of models, by far the greater part of the models which exist are the work of amateurs, who, with indomitable perseverance and few facilities construct them in their leisure time. Quite as frequently as not, these men have had no recognised engineering training, and achieve success by a process of self-education based on a naturally great mechanical aptitude. The amateur model-makers of the country are now largely organised into various clubs and societies catering for their special needs and they deserve encouragement, not only as a potential reserve of skilled workers but as a valuable educational factor in modern life.

The model making industry, craft, or pastime long ago attained sufficient importance to warrant the holding of periodical exhibitions, and the fifth of these, the first to be held since the war, was opened last Saturday at the Royal Horticultural Hall, Westminster. Organised by Messrs. Percival Marshall and Co., under the name of the "Model Engineer" small power Engineering and Scientific Exhibition it not only enables the general public to examine many remarkable mechanical models, but affords a meeting ground for model makers and amateurs together with the firms who supply their requirements. Reviewing the models generally, one is struck by the strong attraction which certain classes of mechanism possess for the amateur. He wants something which will move by itself, so that he can see "the wheels go round." Bridges, or structures or any kind make practically no appeal to his imagination. Machine tools, electrical machinery, or machinery generally find very little favour. An engine is the thing which he wants to make, and among engines the locomotive seems to come first, possibly because success opens up a vista of a complete model railway with an indefinite amount of equipment and apparatus. Traction engines, portable engines, vertical engines of the marine type and stationary open-type engines all have a large following. The gas, or internal combustion engine tempts very few, possibly because it is difficult to make such engines work in very small sizes. Steam turbines are even less popular with model makers, no doubt because, as models they are uninteresting both in appearance and in operation. Model yachts and steam vessels attract many amateurs who have facilities for sailing them, as they both possess that greatly desired feature, the power of moving about.

Referring to the models on view, it is difficult to pick out those works of special mention as they vary so greatly in type that there is no common measure of comparison. Moreover, the density of the crowd of sightseers, among whom enthusiastic schoolboys seemed to predominate, made minute inspection difficult. The most complete railway exhibit is a model railway shown by the Leeds Model Company, Limited, of Balm Road Mills, Hunslet. The line forms a closed oval, occupying four stands, and has bridges, stations, tunnels, signals, sidings, &c., arranged in a most realistic manner. The locomotives are driven by clockwork, and all ordinary railway operations can be carried out in miniature. Messrs. Bassett-Lowke, Limited, of Northampton, have a railway track 42 ft. long laid for both 2½ in. and 1¾ in. gauges upon which they give frequent demonstrations of steam and clockwork locomotives hauling test loads. The numerous models of this firm are well worth inspection, as they include excellent copies of the principal main line engines, corridor coaches, &c., as well as railway equipment, marine engines, &c. Of the amateurs locomotives a ¾ in. model of the N.E.R. locomotive No. 649, by Mr. H. C. Burridge deserves mention. This is of the 4-4-2 type complete with six-wheeled tender. Another good model is a 4-6-4 tank locomotive, built to 1 in. scale by Mr. S. J. Ward. Among the traction engines is a model about 4 ft. long, weighing about 550 lb. and capable of carrying a full grown man as driver. This was made on a farm under most difficult conditions, Messrs. A. J. F. H. and G. W. Eves, the enthusiasts who devoted three years to its construction, having first to make their own lathe from such old iron as they could get. Other traction engines comprise a two-cylinder compound with Stephenson reversing gear and mechanical lubrication by Mr. Malcolm S. Don, a single cylinder model by Mr. H. Taylor and a beautiful little miniature engine about 3½ in. long overall, by Mr. Thos. Barker.

Of the extremely small models, the workmanship of which calls more for the art of the watchmaker than for that of the engineer, we may mention a 4 in. Drummond lathe built to a scale of 1½ in. to the foot, and a sensitive drilling machine to about the same scale. Another small and very beautiful model is that of a six-cylinder Vauxhall motor car chassis complete to very minute detail, by Mr. Ernest W. Fraser. The model general service freight car by Mr. W. H. Spencer is noticeable for the excellent manner in which the pressed steel work of the original has been reproduced. The only other model we have space to mention is that of a 15 in. Mark II howitzer mounting made by Admiral Sir Reginald Bacon. There are no less than 148 models entered for the various competitions which have been organised in connection with the exhibition. In the trade section of the show most of the firms who cater for amateurs and experimentalists are represented. Messrs. Drummond Brothers, Limited, of Guildford, Henry Milnes of Bradford, F. Patrick of Leeds, Cheltenham Works Limited, of Acre Lane, Brixton, S.W., and others show lathes, drills and other metal working machines. Small tools are shown by Messrs. Jones and Shipman, Limited, Leicester; Thorne and English, Limited, Slough; Irwin and Jones, Limited, New London Street, E.C. 3, &c. Wireless apparatus is to be seen in abundance on the stands of the Marconi Company, Limited, Dean Street, Soho, W. 1; F. O. Read and Co., Limited, of Great Queen Street, W.C. 2; G. Z. Auckland and Son, 395, St. John Street, E.C. 1, and other firms.

The exhibition closes to-morrow, January 14, at 10 p.m.

MERCHANT SHIPBUILDING.

IN spite of the fact that the tonnage of merchant shipping returned as under construction in this country at the end of the year was over 1,000,000 tons less than the corresponding figure for the end of 1920, and about 643,000 tons less than at the end of the September quarter of 1921, the optimist may discover in the shipbuilding returns just issued by Lloyd's Register, for the December quarter, some grounds for hoping that the low-water mark of the industry has been reached. We say this because for the first time since September, 1920, the tonnage of vessels commenced during the quarter shows a slight increase, the figure having risen from 51,343 tons in the quarter ended September 30 last, to 55,290 tons in the December quarter, though the number of vessels commenced was the same in each case, viz., 19. The tonnage of vessels launched during the December quarter shows a considerable improvement in comparison with the previous quarter, the figures being 467,246 tons and 307,850 tons respectively and the difference of 159,396 tons, representing an increase of nearly 52 per cent.

The actual tonnage classed as under construction in this country on December 31 last was 2,640,319, as compared with 3,282,972 tons at the end of September and 3,708,916 tons a year ago. The tonnage has thus declined by nearly 29 per cent. during the year and by over 19 per cent. during the quarter. It must also be pointed out that the above-mentioned figure for December 31 includes 722,000 tons on which work has been suspended as well as a certain number of vessels the completion of which has been postponed owing to abnormal causes. The tonnage on which work is now actually proceeding is therefore somewhere about 1,900,000. The total tonnage now in the builders' hands is comprised in 515 vessels, of which 472, making 2,450,283 tons, are steamers, 37 making 188,396 tons are motor vessels, and the remaining 6, which account for only 1,640 tons between them, are sailing ships. The number of vessels of 10,000 tons and over building in this country has declined during the quarter from 62 to 51, the latter figure including 3 between 10,000 tons and 12,000 tons, 21 between 12,000 tons and 15,000 tons, 22 between 15,000 tons and 20,000 tons, 4 between 20,000 tons and 25,000 tons, and 1 between 25,000 tons and 30,000 tons. The tonnage building in this country

for foreign owners has also fallen off, now amounting to 728,643 tons (27·6 per cent.) as compared with 992,869 tons (30·2 per cent.) at the end of September. Of foreign-owned tonnage now building, 141,150 tons is for France and 132,460 tons for Holland.

As would be expected, the work nominally in hand in all the shipbuilding districts of the country shows a considerable reduction in comparison with the figures for the previous quarter, the decrease in the case of the Clyde (including Glasgow and Greenock) amounting to 249,448 tons, or over 20 per cent. The actual figure for the Clyde now stands at 959,714 tons, which amounts to over 36 per cent. of the total tonnage building in this country. The Newcastle district, which comes next in importance to the Clyde, is building 516,776 tons or nearly 20 per cent. of the total, and the figures for the other important districts are: Belfast 321,485 tons (12·2 per cent.), Sunderland, 203,645 tons (7·7 per cent.), and Middlesbrough 134,075 tons (5·1 per cent.).

In general, the situation with regard to merchant shipbuilding abroad appears to be very similar to that in this country, the tonnage now classed as under construction in the British Dominions and foreign countries (excluding Germany) having fallen from 2,260,006 tons (775 vessels) on September 30 last to 1,816,774 tons (611 vessels) at the end of the year. The reduction during the quarter has thus amounted to 443,232 tons, or nearly 20 per cent., while during the year the tonnage building abroad has fallen by 1,654,088 tons, from 3,470,862 tons on December 31, 1920, to the figure given above; the year's reduction thus amounts to nearly 48 per cent. Moreover, work in a considerable proportion of the tonnage now classed as under construction abroad has been suspended, this remark applying to some 400,000 tons, or about 22 per cent. of the total. Italy is the country mostly affected by this feature, work having been stopped on more than half of the tonnage now in the hands of Italian shipbuilders. The decrease which has to be recorded affects most foreign countries, but is most marked in the case of the United States where the tonnage now in hand is but little more than 5 per cent. of that building at the end of the first quarter of 1919. The reduction for that country during 1921 has been 1,093,884 tons, or over 83 per cent., the figure for December 31, 1920, being 1,310,312 tons, while at the end of last year it was only 216,428 tons. Even more noticeable, considering the immense shipbuilding resources of the United States, is the fact that only 5 small vessels with an aggregate tonnage of 1,055 were commenced in American yards during the last quarter of 1921. Shipbuilding work in that country therefore appears to be practically coming to a standstill, which is, perhaps, hardly surprising in view of the fact that the tonnage available is largely in excess of requirements.

Neglecting the fact above referred to that work has been suspended on a considerable portion of the tonnage classed as under construction in Italy, that country now takes the first place among the foreign shipbuilding nations, having in hand 122 vessels, with an aggregate tonnage of 393,832, as compared with 133 vessels and 397,544 tons building at the end of the previous quarter. France takes second place with 76 vessels making 352,635 tons under construction, the tonnage in this case being slightly greater than that for the September quarter, which was 350,681 (87 ships). Holland comes next with 313,879 tons of shipping (123 vessels) in hand, and the United States now takes fourth place, having only 43 ships with a total tonnage of 216,428 in hand, as previously mentioned. Other countries with considerable tonnages of merchant vessels under construction, given in order of magnitude, are: Japan, 35 vessels, 144,912 tons; Sweden, 33 vessels, 78,269 tons; Spain, 16 vessels, 69,937 tons; British Dominions, 34 vessels, 66,469 tons; Denmark, 27 vessels, 63,070 tons; Norway, 40 vessels and 61,559 tons; and Belgium, 8 vessels and 25,491 tons.

Of the vessels building abroad, 445, with a total tonnage of 1,604,138, are steamers, 93, totalling 180,098 tons, are motor vessels, and 73, making 32,538 tons, are sailing ships. Only 18 of the total number exceed 10,000 tons each, and 12 of these are of less than 15,000 tons each. France and the United States are each building 4 vessels of between 10,000 tons and 15,000 tons, and 2 vessels between the same limits are being built by both Japan and Spain. The United States is also building 3 vessels each of over 15,000 tons and less than 20,000 tons, while larger vessels are being built by both France and Italy, the former 1 and the latter 2.

In view of the great importance, at the present time, of the transport of oil in bulk, it may be interesting to mention that, altogether, 121 tankers, each of over 1,000 tons and having an aggregate tonnage of 793,193, are now under construction in various parts of the world. This figure, it may be added, is nearly 18 per cent. of the total tonnage of merchant shipping now in hand. The greater part of these vessels are being built in this country, the actual number and tonnage building in British yards being 82 and 535,019 respectively. The United States is building 12 oil tankers with a total tonnage of 103,890, and of the remainder, 7, making 50,200 tons, are building in France, 8, making 48,000 tons, in Italy, and 4, making 26,400 tons, in Japan.

The motor vessels now in hand number 130, and have an aggregate tonnage of 368,494, which is over 8 per cent. of the merchant shipping building in the whole world. The United Kingdom, as has been previously mentioned, is building 37 of these vessels, making 188,396 tons together, the latter figure representing more than half the total tonnage of motor ships now under construction. Of the motor vessels building abroad, Sweden has the largest tonnage in hand, the figures for that country being 16 ships making 60,347 tons. Denmark and Italy have practically equal tonnages in hand, but the ships building in the former country are, on the average, of larger dimensions. The figures for these two countries are 8 ships, making 30,425 tons, and 32 ships making 30,373 tons, respectively. In the matter of motor-ship construction, the United States takes fifth place, having 3 vessels, with an aggregate tonnage of 19,145, in hand, while Norway and Holland follow, the figures for these countries being 14,220 tons (5 ships) and 13,460 tons (14 ships), respectively. France has only 1 motor ship, of 4,617 tons, in hand, and Japan is not building any vessels of this type at the present moment.

It is perhaps hardly necessary to remind our readers that in the tonnage figures given above, gross tonnages are referred to in all cases, and also that vessels of less than 100 gross tons are omitted from the statistics prepared by Lloyd's Register. In conclusion, we may mention, as a striking testimony to the influence and importance of the society's work, that of the merchant tonnage now building in this country 2,091,356 tons, or nearly 80 per cent., are under the inspection of Lloyd's surveyors with a view to classification by the society. In addition, nearly half of the tonnage building abroad, 889,581 tons to be exact, is being inspected by Lloyd's surveyors, so that the society is responsible for about 67 per cent. of all the merchant shipping now under construction in the world.

CO-OPERATION OF THE CHEMIST WITH THE ENGINEER.

ON Friday last, the 6th inst., a joint meeting of the Institution of Mechanical Engineers with the Society of Chemical Industry was held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, under the chairmanship of Captain H. Riall Sankey, C.B., C.B.E., R.E. (retired). The paper considered was by Mr. G. M. Gill, M.I.Mech.E., of the South Metropolitan Gas Company, and was entitled "The Co-operation of the Engineer and Chemist in the Control of Plants and Processes." This paper we print in full in another part of this issue (page 57).

Dr. W. R. Ormandy, who spoke first on the paper, remarked that so long as colliery owners could sell shale at 3*l.* a ton, they were unlikely to employ chemists. The idea that coal should be bought on the basis of heat units was not new. In the north of England boiler slack could formerly be bought from 3*s.* to 7*s.* per ton, and it was questionable then whether the matter was worth much consideration by manufacturers. Gas works belonged to another category. Now, however, higher prices made payment on the heat unit basis desirable. Several large industrial concerns had been able to make contracts allowing for excess of ash or water. The people of London were condemned to buy anthracite at 20 per cent. to 30 per cent. more than was charged for the same anthracite delivered at Barcelona. Colliery owners were permitted to sell material with up to 25 per cent. of ash, and, unless at great expense, there was no redress or protection. An analogous case was that of all-wool tweeds, which frequently contained not less than 15 per cent. of cotton in the sample and in some cases as much as 65 per cent. In Australia, by way of contrast, heavy fines were imposed on the seller of an all-wool tweed containing more than 5 per cent. of cotton. It was possible to detect a higher percentage, and London merchants sent such goods to Australia under guarantee, and also paid any fines imposed on the middleman.

In France, the bad economy of irregular sized firebricks had been realised, and it was regarded as better to make them to proper size even at the higher price of 50 per cent. on, or more. In connection with the effect of regular firebricks on the life of the furnace, he had once suggested to a firm the use of a firebrick 25 per cent. dearer than the kind used by them. Ultimately, from figures worked out by their own staff, it appeared that instead of 4*l.* per 1,000 it would have been even profitable to pay 40*l.* per 1,000 for the right bricks. The cost of the bricks was, indeed, a very small item, regard being had to the life of the furnace and the various losses incidental to an idle furnace. In France, again, it had been discovered—as was perfectly well known here—that bricks could be made which did not acquire any contraction after leaving the maker's furnace. It was possible to make bricks which, when turned out at a reasonably high temperature, had lost all their contraction. Bricks should be so made that the variation in standard practice should not exceed $\frac{1}{16}$ in. in length. Bricks should be burnt to grog, ground, sieved and mixed in the right proportions with aggregate in order that the voids be filled; then solidified with, say, 20 per cent. of plastic aggregate. In that way it was possible to get bricks which would not contract more than $\frac{1}{4}$ in. in the foot instead of $1\frac{1}{4}$ in. or $1\frac{1}{2}$ in., and which would stand a temperature of 1,200 deg., which was common in industrial furnaces.

Mr. C. W. James said the difficulty in obtaining coal would slowly mend, depending, as it did, upon the human factor. Small coal could be obtained of high purity when crushed to sufficient fineness and washed; all the dirt could be practically eliminated. He had hoped to learn, from the paper, whether more valuable products could be produced by distilling coal at different temperatures from those usually adopted in gas works. He would have liked also to know whether low-temperature carbonisation produced any valuable products, and whether the resulting coke was of higher heating value than the coke from ordinary gas processes.

Mr. E. R. Dolby spoke on the subject of CO_2 records, in stations, factories, &c. The majority of CO_2 recorders were more suited to the laboratory than to the ordinary engineer-in-charge. The CO_2 curves given in the paper showed a percentage of about the standard desired of 18 per cent. There were only two or three departures from the standard, the highest percentage reached being 19·2, and the lowest 16·2 per cent. Could the author say what type of instrument was used—whether of the recording type, and state whether any special precautions were needed in the observations? From his experience in the setting of different types of boilers, he endorsed the author's views on the subject of firebricks. For the setting of water-tube boilers it might be desirable to use, say, Stourbridge firebricks for moderate temperatures and another type, say Glenboig, for positions exposed to excessive heating. There were thus two variables introduced.

Professor J. H. Hinchley remarked that science was organised commonsense based upon experimental determination of natural facts, and much higher standards of efficiency could be reached in manufacturing work by the application of organised commonsense, as indicated by the author. If such men as the author determined that they would have firebricks showing no greater shrinkage than $\frac{1}{16}$ in. in length, and less in breadth and depth, they would get them. The chemical industry of this country owed much of its progress before the war to the

manufacture of plant in Germany, but in this country there existed to-day the same dearth of chemical engineering as before the war. The commercial man was largely to blame; he persisted in employing a man, without knowledge of the subject, to buy his firebricks, and if the latter could be got 5s. a 1,000 cheaper they would be bought. Commercial buyers needed knowledge of the science of the industry in which they worked. He agreed with Mr. Gill's demand for a higher standard of accomplishment; as Dr. Ormandy had suggested, higher efficiency would wipe out increased cost. The low price of the Ford car, by way of instance, was due to the accuracy of its make; there was no waiting, no waste, in its manufacture.

Mr. W. Newton Booth said he would like to ask how the sampling was done by the South Metropolitan Gas Company's office at Newcastle. It was not easy to take an accurate representative sample of 3,000 tons or 4,000 tons of coal; and unless it were accurately taken the result was worth nothing. Had any attempt been made by the company to arrange contracts, based upon the results of testing, in which payment was governed by the actual quality of the coal received? There was great reluctance to adopting new methods of buying and selling coal. So long as suppliers could send 10 per cent. of ash and dirt and obtain payment for it as coal, so long would the practice continue. On the question of firebricks, were the firebricks mentioned hand or machine-made? The variation given was greater than that which he had met with. No one would deny the necessity for co-operation, seeing the possibilities opened up for it by scientific investigation of the various problems arising in an ordinary works. The call of the gas and other industries for continually improving the qualities of refractory materials was being answered by the chemist and various substances had been developed to meet it.

Mr. J. A. Reavell said that the co-operation needed was that of the chemist-engineer. It was beside the point to consider whether the seller should have a chemist or the buyer should have a chemist. He believed that each should have a chemist, and then the chemical engineer would be the one to work out results and present the problem in the proper light. In the case of a certain evaporation plant, the chemist wanted a particular sort of plant, while the buyer—who knew nothing about plant—wanted to purchase at the cheapest price. On the other hand, the chemist was unfamiliar with the mechanical aspect of the plant. On the speaker looking into the matter, he found that the buyer was about to place the order for a plant at a very low price, having obtained an offer embodying the phrase "from and at" which he did not understand, in relation to stipulated evaporations. Take the case of buying tubes for use in chemical works. In caustic soda boiling, solid-drawn tubes were necessary. Here, the various makers, on being asked how their tubes would stand the boiling of caustic soda, would suggest that the best way to find out was to buy them. He received in this connection an offer from the Continent, going into full details with regard to the boiling-points for different densities of caustic soda and recommending a suitable tube. The chemist was valuable to both sides, so that the buyer should know what he was buying and the seller what he was selling.

Mr. E. A. Alliott said that if a perfect chemical engineer existed co-operation would be needless. As matters stood, what was desirable was an engineer with a sound knowledge of engineering and a sufficient knowledge of chemistry to understand the chemist, while the chemist should be able to realise all the practical conditions involved in the plant used. The engineer would know within close limits exactly what was to be done with the material, but the chemist could aid him with advice as to the effect of small variations in the make-up of materials, of impurities, and other matters. The importance of chemical knowledge was also emphasised when the plant was in operation. In filter-press or centrifugal operation, there was not much that an engineer could do to control that operation, except by varying speeds and pressures. The chemical engineer, however, would know that the best output could not be obtained unless the material was in the right state. One material might at one time be comparatively crystalline, at another very gelatinous; this would seriously affect output. The chemist alone could help in such matters. A case in point was that of evaporator plant handling soap lyes. In order to maintain satisfactory output, the chemist must see that there was not too much organic matter in the soap lyes, with its accompanying circulation difficulties; or too much salt, which prevented proper filtering. The chemist also had to keep down the amount of fat in the lye grease, as that would affect the heating surface and output of the evaporator. Plant makers were sometimes asked to guarantee output; the proper way of countering that was to ask for a guarantee for the material to be treated. In designing a plant to give a certain output, the maker could assume that the sample of the required material which had been submitted to him was a a fair and good sample, or he could assume that the material he would ultimately handle would be inferior to the sample. On the first assumption it was necessary for the chemist or chemical engineer to do his work properly, if the stipulated output was to be reached. On the second assumption, a larger plant than that actually needed would have to be installed. He trusted that when facts were realised it would be unnecessary to put in larger plants to allow for defects in reasonable control when it would be possible to keep down initial costs and costs of running and maintenance to levels which allowed for competition elsewhere.

Mr. W. A. Tookey also advocated greater co-operation between the engineer and the chemist. The engineer at present might be said to speak an entirely different language from that of the chemist, and more such joint meetings as the present would assist communication and therefore co-operation. The two professions were not in sufficiently intimate touch with each other. Mr. Gill had shown how great a difference variations in raw material made in the manufacture of gas. It should be borne in mind that the difficulties which the author had met with were chiefly dependent upon the volatile matter of the coal. He would ask whether those difficulties would be so great if, by some alteration of process, the yield of "volatiles" were somewhat diminished? Could not cheaper and better gas, and gas of more regular quality be obtained, if the coke product was given more attention than at present?

Mr. R. C. McDonald stated that Carnegie had claimed to be the first to introduce chemical control into the manufacture of iron in the United States. Carnegie found, as a result of his enterprise, that a great deal of iron ore which had previously been thrown aside as unsuitable turned out to be the most valuable that he could use.

Mr. M. Jockel said that figures he had were based on personal tests of some 50,000 tons of coal delivered during the year 1921, at the works in London, at which he was employed; the tests made supported Mr. Gill's statement as to the enormous variation in the coal. The coal was Midland coal, coming some 150 miles to the metropolitan area. Taking rough averages (during 1921) the total moisture in the fuel delivered at the works was 11·3 per cent. by weight; the volatile matter averaged 24·2 per cent. for the year; the fixed carbon—or carbonaceous content—was 59·2 per cent., and the ash 16·5 per cent. for the year. Being also interested in the minima and maxima, he had found that the minimum total moisture on a test was, for 1921, 2·7 per cent., the maximum being 19·6 per cent. Of volatile matter, the minimum was 23 per cent. and the maximum 32 per cent., while the fixed carbon minimum was 52 per cent. and the maximum 69·9 per cent. The ash minimum was 5·6 per cent. and the maximum 32·2 per cent. From these results he had excluded the three months' deliveries during the coal strike. From the boiler-house standpoint, these figures revealed a sad state of affairs. The furnace efficiency was "all over the shop," and high boiler efficiencies could not be maintained. With regard to sampling and assaying the coal, the United States took up this question much earlier than this country had, with more or less satisfactory results. He entirely endorsed Mr. Gill's remarks about refractories. Only that day he had inspected refractory work in a furnace, and had been impressed by the variation in the sizes of the bricks. Some of these variations exceeded those cited by Mr. Gill, and, what was worse, was the consideration of the time occupied in sorting them out, amounting to at least 10 per cent. of the labour cost involved in the furnace with steam boilers of the water-tube type. With regard to the question of CO_2 contents, he feared that steam engineers could not in practice reach such figures as 18 per cent. Above 14 per cent. or 15 per cent. he had found trouble ensued with the refractories. Oil fuel was particularly severe on refractories, the latter being sometimes so punished as to render maintenance impossible.

Mr. W. H. Patchell said he would be glad to see realised what engineers had been fighting for, namely, a closer co-operation of the two professions, and also closer relationships between the various learned and technical societies; it would be for the public good that the latter should see more of each other and discuss matters of common interest generally. He could not agree that the chemist had a separate language; indeed, when things went badly, the engineer and chemist could quite understand each other. Quoting from a paper by Mr. Cramp, read before the Iron and Steel Institution in America, it could be shown how the chemist and engineer required to work together. It appeared that 10 per cent. of the sulphuric acid made in America was absorbed by one steel company alone. No less than 600,000 tons of sulphuric acid were handled by the American steel industries, 10,000 tons of hydrochloric acid, 2,000 tons of sulphur, 3,700 tons of sal ammoniac and so on. On the question of ash and dirt contents in coal supplies, in the case of collieries with which he had mostly to deal, the coal was passed over a 2-in. screen. It then was sent over a picking band slowly; with luck, or, if the colliery owner was so inclined, it was sent to a washery, and it certainly paid now, in view of the heavy carriage cost, to buy washed coal. By means of the froth flotation process, an extraordinary amount of dirt could be taken out of fine dust coal. What with picking, rough washing and the froth flotation process there was no limit to the degree of cleanliness to which coal could be washed; it was purely a question of paying for it. With regard to Mr. James's remarks, in London it was necessary to take what could be got; personally, he had bought anthracite at 5*l.* a ton and had had to buy other coal to burn it! On the subject of firebricks, it was important that the bricks should match up. He condemned the use of ordinary bricks for the outer part of a boiler setting and firebricks for the fireside. He had never found a glazed brick which would match up with the firebrick. The cost of brick setting was a more important consideration than the cost of the bricks. It would be profitable to pay the higher price for good bricks. For instance, some people were using carborundum, and there it was not a matter of what was paid per 1,000, but what was paid per brick. In his view, there were sellers on the road who should be poisoned; there were also sellers that a buyer would be glad to meet and loth to part from; people should not be put on the road to sell candles one day, and the next day, perhaps, piston rings.

Mr. G. M. Gill then replied to the discussion, which, he remarked, had yielded much information not given in the paper. Mr. James and Mr. Patchell had both spoken of washing the coal. Not many gas works used washed coal; in fact, he did not know that there was much available for gas works. It should not be forgotten that a good deal of water was left in the coal, and in gas-making this water had to be dried out; a good deal of ash was lost, but a good deal of water was gained. Gas works generally were not yet enamoured of the low-temperature process; there were many "snags" in it, and gas engineers could see more money in what they were doing than in what they were not doing.

With regard to the CO_2 figures submitted, of course the company's producers were deep ones with a deep bed of fuel, and therefore there was not much to be said about the figures; there was no difficulty in working the producer within something like the limits quoted with ordinary control. The apparatus used was the ordinary Orsat apparatus. His company had made a practice of using bricks which expanded at one part of the setting, and at

another part bricks which contracted, thus counteracting the effects. The better course—gradually becoming possible—was to use bricks which neither expanded nor contracted. Before the war, his company went to Germany for their retorts, the necessary material not being available here. As the company had 18 miles of retorts, the question was an important one. In their sampling at Newcastle the coal was tipped down chutes into the ships, and as it came down something rather like a bucket at the end of a stick was immersed in the coal at fairly frequent intervals during the loading of the cargo. The quantity sampled from a cargo was quite large. The system had appeared to commend itself to collieries, and it gave rise to very few disputes. The collieries received particulars of the results. It had been contended that it was the fault of the buyer if he did not get the material he asked for; to some extent it was, but if no one could be found who was making what was wanted, it became a question of taking what was available.

The Chairman then brought the proceedings to a close, announcing that an extraordinary general meeting of the Institution of Mechanical Engineers would be held on Friday, January 20, at 6 p.m., to consider an alteration of the Articles of Association, followed by a general meeting at about 6.30 p.m. The paper to be read would be "Some Observations on Producer Gas Power Plants," by Messrs. Denny and Nibbs.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

(*Concluded from page* 20.)

As would be expected in an exhibition of this character, the exhibits of apparatus for purely engineering applications were by no means numerous, and such instruments as were displayed in this category would be familiar to most of our readers. These remarks apply particularly to the steam-flow meters exhibited by Messrs. George Kent, Limited, 199 to 201, High Holborn, W.C. 1, and to the indicating, recording and integrating apparatus for measuring the flow of water over V-notches and rectangular weirs shown by the Lea Recorder Company, Limited, Deansgate, Manchester. The latter firm also exhibited photographs illustrating the applications of their well-known coal meter for use with chain-grate stokers. With another integrating apparatus for water-flow meters, described as Shotter's integrator, and shown at the stand of Messrs. H. Tinsley and Co., South Norwood, S.E. 25, we hope to deal more fully later, but we may here mention that it depends for its action upon the alteration of the resistance of one arm of a Wheatstone bridge by the variation in the head of water flowing over a notch. The position of the pointer of an indicating instrument is automatically marked at short intervals on a chart, so that a continuous record of the flow is obtained.

The importance of accurate temperature measurements in scientific and industrial work was well exemplified by the number of pyrometers and thermometers shown by various firms. In addition to those referred to in our previous article, we noticed the distant reading and recording mercury thermometers shown by Messrs. Negretti and Zambra, 38, High Holborn, E.C. 1, which were illustrated and described in our columns on page 736 of vol. cx. A pyrometer of the disappearing filament type, similar in principle to that described on page 20 of our last issue, was also shown by Messrs. H. Tinsley, whose address is given above, and Messrs. Gambrell Brothers, Limited, Merton-road, Southfields, S.W. 18, exhibited examples of portable and wall-type temperature indicators for thermo-couples. Messrs. Siemens Brothers, Limited, Woolwich, showed temperature indicators of the fixed and portable types, and also a suspended-coil recorder for use with thermo-couples or resistance thermometers.

The Foster Instrument Company, of Letchworth, showed their well-known "Resilia" recorders for use with radiation pyrometers or thermo-couples, as well as indicating pyrometers and a platinum resistance thermometer specially suitable for measuring low temperatures. Their most interesting exhibit, however, was a new piece of apparatus for controlling the temperature of industrial furnaces. It should first be explained that this apparatus is intended not only to keep a furnace at a constant temperature, but to raise or lower the temperature in accordance with a predetermined programme. In this apparatus, a thermo-couple in the furnace is connected to a recorder and the pen arm of the recorder is arranged to form one part of a divided electrical circuit. In one part of this circuit a contact is made when the pen arm is moved over towards the ink drum by the clockwork mechanism, and the other part of the circuit is completed when the pen is pressed down on to a metal plate fixed over the chart. The metal plate is cut to form a template of the desired temperature record, and when the temperature of the furnace, as indicated

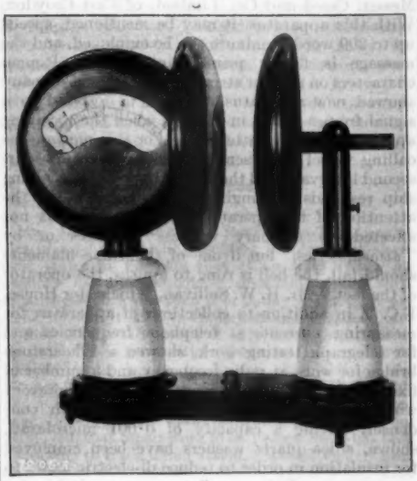
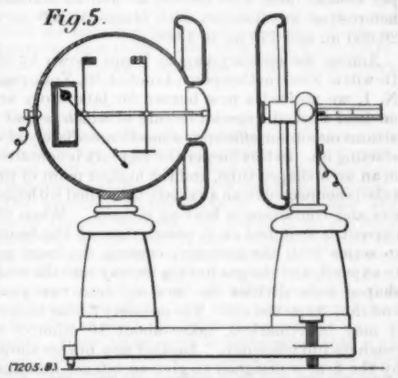


FIG. 4.

Fig.5.



EXTRA HIGH-TENSION ELECTROSTATIC VOLTMETER; MESSRS. EVERETT, EDGECUMBE AND CO., LIMITED, HENDON.

by the pen, is less than the required amount, the depression of the pen makes contact with the template and completes a circuit through a relay. The relay operates a motor to cut out resistance from the heating circuit of the furnace and thus increases its temperature. Afterwards, when the pen is moved over to the ink drum, the other circuit is closed through another relay which operates a motor to increase the resistance in the heating circuit and so reduce the supply of heat to the furnace. The reduction is, however, less than the previous increase, and as long as the temperature remains below the normal the difference will tend to increase the heat supply. If, on the other hand, the temperature rises too high, the pen makes no contact with the metal template when depressed, so that there is no increase in the current supply, but the contact with the other circuit, which lessens the current, is made as before, and the temperature of the furnace is reduced to the normal.

Several well-known firms showed electrical measuring instruments for switchboard and laboratory use, but our space only permits us to refer to a few of these. Messrs. Everett, Edgcumbe and Co., Limited, Hendon, N.W. 9, exhibited an extensive collection of their products, but of these we can only mention the extra-high tension electrostatic voltmeter. A photograph of this instrument is reproduced in Fig. 4 annexed, and the diagram, Fig. 5, indicates the principle of its action. As will be gathered from the illustrations the electrostatic attraction between two oppositely-charged conductors, which are protected by guard rings, is caused to move a pointer over a graduated dial. In the instrument exhibited the dial was graduated up to 40,000 volts, but the range could be extended to 100,000 volts by increasing the distance between the plates. It follows, of course, that since air is used as the dielectric in these instruments, the readings are identical for direct current or for alternating current of any frequency. Similar instruments are made for any range between 10,000 volts and 200,000 volts.

A notable feature of the exhibit of the Weston Electrical Instrument Company, Limited, Audrey House, Ely-place, E.C. 1, was a new thermo-ammeter for measuring the high-frequency currents used in wireless telegraphy. The instrument consists of a heating element, through which the current to be measured passes, and a thermo-couple in contact with the heater. Leads from the couple are connected to a moving-coil instrument graduated so as to read directly the current passing through the main circuit. These instruments are made in standard ranges of from 1 ampere to 750 amperes, and they are guaranteed to be accurate within 1 per cent. of full-scale value on either radio-frequency or audio-frequency currents.

Messrs. Evershed and Vignolles, Limited, Chiswick, W. 4, illustrated the development of their well-known "Megger" insulation testing instruments from the ohm-meters and separate generators first made in 1888. A number of instruments based on the ohm-meter principle and used for signalling work, especially on ships as helm indicators, steering telegraphs, &c., were also shown, as also were Needham's pulsator speed indicators, which we described on page 36 of vol. cxi, in dealing with last year's exhibition. The Crompton-Robertson stroboscopic vibrator for speed measurement, also referred to in our account of last year's exhibition, was again shown by Messrs. Crompton and Co., Limited, of Chelmsford, who also exhibited a new line of milliampere meters especially suitable for X-ray and electro-medical equipments. These instruments, which are of the moving-coil type, are small and neat in appearance and are provided with internal shunts to increase the range. The shunts are put in circuit by turning a knob on the case of the instrument and a small dial, visible through a slot in the face, automatically indicates the maximum value of the range actually in use. Messrs. Elliott Brothers (London), Limited, of Lewisham, S.E. 13, showed a selection of long-scale switchboard instruments, as well as galvanometers, ohmmeters, testing sets, telegraphic apparatus, and several other of their well-known products, while Messrs. Nalder Brothers and Thompson, Limited, Dalston-lane, E. 8, exhibited insulation-testing sets, power-factor meters, a synchroscope and a wide range of measuring instruments of the switchboard and portable types. Mention should also be made of the resistance boxes and bridges, potentiometers, galvanometers and other measuring instruments shown by Messrs. Gambrell Brothers, Limited, Merton-road, Southfields, S.W. 18. This firm also exhibited carbon rheostats of a new design arranged so that any number of units can be bolted together and used in series or in parallel.

Messrs. H. Tinsley and Co., some of whose exhibits have already been referred to, showed their sine-wave rotary converter which is an electromagnetic machine used for investigations in connection with submarine cables and capable of producing currents at frequencies ranging from 5 cycles to 50 cycles per second. The design is such that distortion of the wave form by eddy currents or leakage is reduced to a minimum, all the fittings being of nickel silver and the armature having a smooth core to avoid the harmonics which would be set up by the usual toothed core. Another interesting exhibit by this

firm was a low-frequency sine-wave generator which is used for similar work to that above-mentioned. It consists of a rheostat over which a sliding contact is drawn backwards and forwards, the reciprocating motion being obtained by means of a steam-engine mechanism with a long connecting rod. The terminals of a battery are connected to the opposite ends of the rheostat, and the low-frequency output is obtained between the sliding contact and the middle point of the battery. The long connecting rod gives the sliding contact a sufficiently near approximation to simple-harmonic motion, and by altering the speed of the driving mechanism, the frequency can be varied from 0·1 cycle to 10 cycles per second. The actual frequency is measured by a reed indicator stepped up in the ratio of 50 : 1. Inductance and capacity bridges, potentiometers and a variety of measuring instruments were included in the firm's exhibit, but lack of space prevents our making further reference to them.

Messrs. Isenthal and Co., Limited, Denzil Works, Willesden, N.W. 10, showed a range of electrostatic measuring instruments designed by Mr. G. L. Addenbrooke. These included a voltmeter suitable for any pressure between 50 volts and 1,000 volts, and a low-reading voltmeter which can be arranged to give a deflection of 5 cm. per volt on a scale placed 2 m. from the instrument. A number of rheostats of particularly serviceable appearance was also shown by this firm. Most of these were operated by screw mechanism, but in one we noticed, the sliding contact could be moved directly by hand as well as by screw gear. The hand adjustment, of course enables the user to move the contact rapidly from one end of the coil to the other, while the fine adjustment can be effected by the screw gear in the usual way. In another design shown, the movement of the slider was effected by means of a hand wheel connected with a system of stranded wires arranged on the principle of the differential pulley block, but inverted so as to give a large and rapid movement of the slider for a small turn of the wheel. The Zehnder type high-tension accumulators shown by the firm consist of a number of pairs of plates immersed in test tubes containing acid, each test tube being mounted on a porcelain pedestal with oil insulation. They are made up in 40-volt banks and can be connected in series to give pressures up to 4,000 volts without any additional insulation. In wireless work they may be employed to furnish the plate voltage required for valve working, and they have numerous applications in connection with testing work.

Two interesting instruments were shown by the Cox-Cavendish Electrical Company, Limited, Actonlane, N.W. 10, but considerations of space prevent us from describing them in detail. One of these was a gold-leaf electroscope designed by Dr. E. A. Owen, of the National Physical Laboratory, and it may be noted that the method of letting rings of sulphur into the ebonite to improve its insulation is employed for supporting the rod carrying the gold leaf. The latter is 4·5 cm. long and the insulation is such that the end falls about 0·11 mm. per hour with a potential of 280 volts. The sensitiveness is indicated by the fact that a potential change of 1 volt. on the leaf moves it through 0·51 mm. The other instrument shown by this firm was the electrostatic oscillograph of Professor Taylor Jones ; it can be used with potentials ranging from 5,000 volts to 250,000 volts.

Diathermy, as our readers are doubtless aware, is the name given to the process of heating the tissues of the human body by means of comparatively heavy currents of high frequency, the heating effect, which is used for medical purposes, being due to the resistance of the tissues to the passage of the current. Portable apparatus for this purpose was exhibited by Watson and Sons (Electro Medical), Limited, 43, Parker-street, Kingsway, W.C., who also showed a combined X-ray outfit consisting of a couch, screening stand and tube stand, and a 1·8-kw. oil-immersed transformer wound from a secondary voltage of 60,000 and suitable for operating a tube taking from 10 milliamperes to 30 milliamperes. For use in connection with X-ray work, this firm also showed a voltmeter with which, we were informed, voltages up to 250,000 can be measured to within about 2 per cent. The instrument consists of two silvered metal spheres, 10 cm. in diameter, mounted one over the other in a frame. The upper sphere is fixed and the lower one is drawn up by means of a silken cord, until a spark passes between the two spheres. The distance apart of the spheres is a measure of the voltage, which is indicated by a suitably calibrated scale. Certain corrections have, of course, to be applied to allow for atmospheric conditions.

Wireless apparatus was shown by several firms, and by Mr. J. Scott-Taggart, who exhibited a receiving set including the "Negatron" negative-resistance valve described by him in a paper read at the Edinburgh meeting of the British Association, and reproduced on page 584 of our last volume. Apparatus for high-speed working was shown by Messrs. Creed and Co., Limited, of East Croydon. With this apparatus, it may be mentioned, speeds up to 200 words a minute can be employed, and the message is finally printed in ordinary Roman characters on a paper strip. The Marconi Company showed new apparatus designed to respond to a signal from a vessel in distress when the receiving apparatus is left unattended. For this purpose the calling vessel must send two long dashes at four-second intervals, and the apparatus on the receiving ship responds by ringing a bell, thus calling the attention of the operator. The apparatus is not affected by ordinary wireless messages or by "atmospherics," but if one of the valve filaments should fail, the bell is rung to apprise the operator of the fact. Mr. H. W. Sullivan, Winchester House, E.C. 2, in addition to collections of apparatus for measuring currents at telephone frequencies and for telegraph testing work, showed a Wheatstone bridge for work at radio frequency and a number of fixed and variable air condensers for laboratory work. In the standard laboratory fixed air condenser, having a capacity of 0·001 microfarad, shown, silica-quartz washers have been employed for insulation in order to reduce di-electric losses to a minimum. Valve oscillators, one suitable for very low frequencies of from 5 cycles to 400 cycles per second, were also shown, as well as standard heterodyne wave meters with ranges of 150 m. to 20,000 m. and 150 m. to 4,000 m.

Among the mercury-vapour lamps shown by the Hewittic Electric Company, Limited, 80, York-road, N. 1, we noticed a new burner for laboratory and medical work the special feature of which is that it attains maximum efficiency almost immediately after starting up, In this burner the mercury is contained in an arch-shaped tube, and the highest point of this tube is connected to an auxiliary tube filled with inert gas and containing a heating element. When the current is switched on it passes through the heater in series with the mercury, causing the inert gas to expand, and the gas forcing its way into the arch-shaped tube divides the mercury into two parts and thus starts the arc. The ordinary tilting burner, it may be remarked, takes about 10 minutes to reach its full efficiency. Another new burner shown by the firm is designed to give an intense illumination from the end of the mercury tube, and is especially suitable for polarimetry, microscopy and other scientific uses in which a small and brilliant source of monochromatic light is required. The "Pointolite" tungsten arc lamp of 4,000 c.p. shown by the Edison-Swan Electric Company, Limited, Ponder's End, Middlesex, and referred to in our account of last year's exhibition, is now a commercial product and we understand is being applied to kinematograph work. It can be supplied for voltages ranging from 90 to 250, and has an efficiency of about 0·25 watt per candle power. The firm also showed a lamp of this type giving 10,000 c.p., and having a globe some 15 in. in diameter. The efficiency, in this case, is about 0·2 watt per candle power, and this figure will probably be improved. For running "Pointolite" lamps off an alternating-current supply the company showed a mercury-vapour rectifying set suitable for 500-c.p. lamps, and also a rectifier set for smaller lamps employing a "Tungar" gas-filled valve. Unfortunately, we have insufficient space to deal with some other interesting developments in "Pointolite" lamps, but we should mention that the firm, showed a series of gas-filled incandescent lamps, the bulbs of which are made from white glass so that the filament is invisible and a more diffuse light is obtained. Other lamps of this type shown were made from transparent glass of a bluish tint in order to compensate for the excess of red rays, and the resulting light is said to have a spectrum closely resembling that of daylight. These lamps are intended for use where colour matching has to be carried on in artificial light. "Daylight" lamps, or lanterns, fitted with screens of specially-tinted glass for modifying the colour of the light from incandescent lamps so as to simulate daylight were also shown by Messrs. A. W. Penrose and Co., Limited, 109, Farringdon-road, E.C. 1, together with numerous instruments and appliances for photo-process work, colour testing and measurement.

For the projection of opaque objects such as diagrams, book illustrations, printed matter, &c., Messrs. Newton and Co., 72, Wigmore-street, W. 1, showed the "Episcope," which was referred to in our article on last year's exhibition. This instrument consists of a box containing two powerful gas-filled lamps fitted with special reflectors. In the upper side of the box is a 20-in. Aldis anastigmat lens, and above the lens is a plane silvered mirror which can be tilted at an angle of 45 deg., or thereabouts. The object to be projected is placed in the bottom of the box, and, being brightly illuminated by the lamps, its image formed by the lens is directed by the mirror on to a white screen fixed on the wall. Auxiliary apparatus can be provided for the projection of ordinary transparent lantern slides. Since last exhibited, the apparatus has been mounted on a wheeled trolley so that it can easily be moved from place to place, and a rising and falling table has been provided in the bottom of the box to enable books of varying thicknesses to be placed in the focal plane of the lens. Messrs. Newton also showed an attachment for ordinary lanterns for projecting microscopic objects and for experimental demonstrations in spectroscopy and with polarised light. Polarimeters, saccharimeters and refractometers were exhibited by Messrs. Bellingham and Stanley, Limited, 71, Hornsey Rise, N. 19, and optical instruments and apparatus for ophthalmic work were shown by Messrs. G. Culver, Limited, of Pentonville, N. 1. A fine display of lenses for photography and kinematography was arranged by Messrs. J. H. Dallmeyer, Limited, of Willesden, N.W. 10, and we may mention that their recent productions include a series of "Pentac" anastig mat lenses made with focal lengths ranging from 1½ in. to 6 in. and working at the very large aperture of F/2·9. Photographs taken with these lenses were exhibited to show their remarkable definition and covering power. The only other photographic exhibit we noticed was that of Messrs. Ilford, Limited, who had an illuminated revolving stand with a spectroscope attached to enable the absorption spectra of various colour filters to be examined. They also demonstrated a new colourless filter, known as the "Q" filter, for cutting out ultraviolet light. This filter is claimed to be quite permanent, and in comparison with the ordinary æsculin filter it is certainly more opaque to ultraviolet light and, less fluorescent.

Meteorological and surveying instruments were shown by Messrs. C. F. Casella and Co., 49 and 50, Parliament-street, S.W. 1, their exhibit including Dr. J. S. Owen's filter for measuring the suspended impurities in city air and described by him in a paper read at the Edinburgh meeting of the British Association. This paper was reprinted on page 555 of our last volume. Messrs. W. Ottway and Co., Limited, Orion Works, Ealing, showed telescopes for astronomical and terrestrial observations, as well as sextants, theodolites and levels. Navigating instruments, including sextants, course and distance indicator, position line and slide rule, &c., were shown by Messrs. Henry Hughes and Son, Limited, 58, Fenchurch-street, E.C. 3, but the most interesting exhibits of this firm were the Campbell-Bennett aperiodic compass and the Booth bubble sextant for aerial navigation. The aperiodic compass, as its name implies, is quite dead beat in action ; that is to say, it returns to the north pointing position, after having been displaced, in one direct movement. It is of the liquid type, and the "card" consists of eight thin wire arms extending from a small central ring. The card has a very small moment

of inertia and the arms, while offering considerable resistance to rotation, are practically free from the drawback encountered with vanes or paddles of dragging the liquid round with them, and thus increasing the effective inertia. In spite of its dead-beat characteristic, the compass is by no means sluggish in action, and it is remarkably steady under casual disturbances. The azimuth degree marks are engraved on a rotatable verge ring, which also carries a series of parallel grid lines running in the north-south direction, and the pilot steers by keeping the lines parallel with the north-south wire of the card. The verge ring is previously set for the course desired by turning it until the degree mark of the course comes opposite the forward lubber line. There is therefore no necessity for the pilot to keep the course he is steering constantly in mind, and he is also free to move his head into any position without introducing an error due to parallax.

The principle of the bubble sextant is that the image of the celestial object of which the altitude is required is superposed on the image of a bubble, seen through a collimating lens, by means of a transparent reflector corresponding to the index mirror of a marine sextant. Owing to the arrangement of the optical parts, the bubble and celestial object do not move relatively to each other when the instrument is moved as a whole, so that the observer can make his coincidence in the ordinary way. The reading is obtained on a large divided drum graduated in intervals of 10 minutes of arc, but it is possible to estimate to 3 minutes. Two adjustable shades, by means of which the light transmitted can be regulated to any desired extent, are provided, and the bubble is illuminated by an electric lamp, the light from which can be adjusted by a variable resistance. The divided drum can also be illuminated for night work.

Microscopes and photomicrographic apparatus were shown by several firms, including Messrs. R. and J. Beck, Limited, 68, Cornhill, E.C. 3, Messrs. W. Watson and Sons, Limited, 313, High Holborn, W.C. 1, Messrs. F. Davidson and Co., 29, Great Portland-street, W., and Mr. Charles Baker, 244, High Holborn, W.C. 1. The "Talyden" workshop microscope referred to on page 35 of vol. cxi was again shown by Messrs. Taylor, Taylor and Hobson, Limited, of Leicester, together with a later model designed for higher power work, and giving a magnification of 150 diameters. The latter instrument is especially suitable for measuring the indentations made in Brinell tests on very thin specimens, for which light loads giving small impressions must be employed. To facilitate this work, and other measuring operations, the eyepiece is fitted with a graticule having two scales at right angles covering a distance of 0·8 mm. in both directions. Rack focussing gear, giving a total adjustment of 3 in., is provided, and in order to take up backlash the rack is divided longitudinally into two parts, one of which is fixed while the other is spring urged. The sliding part of the instrument has a three-point bearing on the stand, formed by two vees and a flat. These points, and other features of the design, indicate that great care has been taken to produce a substantial instrument suitable for the comparatively rough work for which it is to be employed.

Another new production of the firm is an indicator of the dial-gauge type known as the "Talymin," and intended for measuring the external diameters of small manufactured parts to within less than 0·0001 in. The part to be measured is placed between an anvil and a moving pin, and the movement of the latter, magnified 400 times, is shown by a pointer and scale. The magnification is obtained without the use of knife-edges by employing a differential roller around the larger part of which passes a band connected to the moving pin. This band is kept taut by a spring and a second band is passed round and secured to the smaller part of the roller, the other end of the second band being connected to a fixed point; the indicating pointer is connected to the axis of the roller. Movement of the first-mentioned band causes the roller to roll along the other band and the arrangement constitutes a lever, the short arm of which has a length equal to the difference in the radii of the two parts of the roller. The actual difference in radius is 0·01 in., and as the length of the pointer is 4 in., the movement is magnified 400 times, as previously stated. The advantage of the arrangement is that friction and wear are practically eliminated so that no lubrication is required; backlash is also avoided.

Of the few remaining exhibits we may mention those of laboratory apparatus by Messrs. J. J. Griffin and Sons, Limited, Kingsway, W.C. 2, and Messrs. A. Gallenkamp and Co., Limited, Sun-street, Finsbury-square, E.C. 2, the latter firm showing tube, muffle and crucible furnaces as well as electrotitration apparatus and apparatus for experiments in physical chemistry. Messrs. L. Oertling, Limited, Turnmill-street, E.C. 1, showed a selection of balances for chemical and assay work. Drawing instruments were displayed by Mr. W. H. Harling, 47, Finsbury Pavement, E.C. 2, and by Messrs. H. Hughes and Son, Limited, whose address has been given above. Calculating slide rules for ordinary work and for special applications were shown by Messrs. Tavernier-Gravet (A. Leroy), of 19, Rue Mayet, Paris, and cheap slide rules and mathematical scales for students' use and demonstration purposes were exhibited by Mr. C. W. Hansel, 8, St. Andrew's-road, Bedford.

INDUSTRIAL NOTES.

MR. LEONARD ROPNER, Stockton-on-Tees, senior vice-president of the Shipbuilding Employers' Federation, states in *Fairplay* that at no time within his memory has the outlook in shipbuilding and ship-repairing been worse than it is to-day. Yet there are signs, he adds, that both employers and workmen have learned in the sad school of experience that nothing short of the most drastic adjustment in costs could possibly bring health to British shipbuilding. Mr. Ropner further says that where work is available output is improving. On the other hand, it is reported from Barrow, where many shipyard workers are unemployed, that repair work to an Italian vessel has been lost owing to trade union action. Messrs. Vickers were in hopes of securing the contract, which would have involved working during the Christmas and New Year holidays owing to the short time allowed for the work. The Boilermakers' Society prohibited members from undertaking the job although extra pay was offered the men, and the work is to be done elsewhere. This shows that there is still much room for improvement "where work is available," to use Mr. Ropner's own terms.

The above remark is a comment on a statement which Sir Walter Runciman is reported to have made a few days ago, to refute assertions made by "misinformed politicians" to the effect that "they see signs of improvement in trade." Sir Walter Runciman said: "The hundreds of thousands of worthy men and women who are workless, and willing to do anything rather than accept charity, may well ask why they are not employed if trade revival has set in." We very much fear that this is not a statement of actual fact, for many unemployed, whilst loudly professing that they "can do anything," are most particular in regard to the class of work put before them and the wage it carries. Many refuse even to contemplate that work for one moment; numerous others throw it up after a few days' trial on the plea that it is not congenial to them, or is in the country, and what not, returning to "charity" in which they are getting dangerously rooted. This unfortunate state of things may last a long time, since unemployment is now "organised." When an unemployed refuses a job which he can do and is unable to give a valid reason for his refusal, all "charity" should cease there and then. As matters now stand the "doles" system is having a most demoralising effect upon the nation.

At last there is a break in the most serious barrier to honest work that has ever been erected in this country (the United States), says *Engineering News-Record*, New York. The crime of 1916—whereby the railroad workers were given 10 hours pay for 8 hours work, with all the consequent overtime evils—has been struck a blow by the Railroad Labour Board. It is true that the relief applies only to a small part of the railroad field and does not affect the brotherhoods favoured by the infamous Adamson law. That law, however, was the precedent which was followed in giving the 8-hour rule to the maintenance-of-way forces. Under a decision of the Railroad Labour Board rendered in the middle of December, the 8-hour day is not abolished, but the provision by which time and one-half had to be paid for overtime in excess of 8 hours is abolished. The nominal rate is now to apply up to 10 hours of continued service, after which the time and one-half rate will be enforced. Time and one-half is also abolished for Sunday and holiday work. The decision is a substantial step forward, adds our American contemporary.

A correspondent of *The Birmingham Post* gives interesting figures on Germany's production and exports of steel. According to the German Government publication *Wirtschaft und Statistik*, the make of steel in Germany in 1919 amounted to 6,732,000 tons, and in 1920 to 7,710,000 tons. While the tonnage for the former year may be accepted as being correct, that for the latter seems to be an under-estimate. In certain English circles, the steel output in Germany in 1920 was estimated at quite 8,000,000 tons, whilst American estimates put the total at 8,400,000 tons for that year. American estimates of the German steel production in 1921 are 9,400,000 tons, which, if correct, would prove that Germany was last year the only country in the world to increase her output of steel. An English computation would put the total at 10,000,000 tons for last year. The German Minister for Economic Affairs stated a short time ago that about 20 per cent. of Germany's production of steel was being exported. As the exports of iron and steel at that time were exceeding 200,000 tons per month, this would imply a rate of production of 1,000,000 tons per month, which quantity is certainly an exaggeration at present. At the same time it had to be borne in mind that the German steel export trade was slack in the early months of last year, and the monthly quantities which were then being exported were considerably less than those in the first months in the second half of the year. The Government figures for January to April, inclusive, have so far been withheld from publication, but those for the six months ended with October show the somewhat astonishing total exports of iron and steel amounting to 1,181,000 tons, or at the rate of 2,362,000 tons per annum. But, as already mentioned, the export trade was not very active in the early months of 1921, and the total for the year can therefore be assumed not to have surpassed 2,000,000 tons, which would be a much better showing than that in 1920. If, then, total exports of 2,000,000 tons can be accepted as correct for 1921, and if account is taken of the Minister's statement of 20 per cent. of the production being exported, it is obvious that the output of steel in Germany last year must have been somewhere in the neighbourhood of 10,000,000 tons, as previously suggested.

The daily press is at the present time devoting a part of its space to a scheme which is being put forward "for the co-ordination of trade union efforts," the object being the formation of a new triple alliance between trade unions, the co-operative movement and the Labour Party, the combination to be fully representative of the workers as consumers, producers and citizens. We hope to be able to report upon this scheme when it has matured somewhat. We should, however, like to take this opportunity for stating that manual workers—and we believe that manual workers alone are contemplated in the above—are always much too prone to qualify themselves as "producers," they being in their own mind the only producers who count for anything. They should remember that "not a brick was made but some man had to *think* of the making of that brick," as Carlyle puts it, and ever since that man thought the matter out the manufacture of bricks has become a possibility. The same applies to every manufactured article in every trade.

Writing in *Unity*, the journal of the National Alliance of Employers and Employed, Mr. J. J. Burton, of the Tees Furnace Company, Limited, refutes statements made in the same journal by the Right Hon. John Hodge, M.P., one of these being to the effect that "looking back over an experience of forty years in the trade, he had never yet known a big reduction of wages to result in the starting of a single extra furnace." Mr. Burton shows that the experience of the industry clearly demonstrates that since the coal strike, while wages have steadily fallen, output of pig-iron has begun to recover. The number of furnaces in blast was 300 at the end of September, 1920, 109 at the end of March, 1921, 1 at the end of June, 1921, 82 at the end of October, 1921, 85 at the end of November, 1921. After dealing further with the situation, he adds that the present high wages cost in some of the industries on which the iron and steel trades depend is one of the principal causes why more furnaces are not now lighted. The enormous increase in fuel and transport charges keeps up the cost of making and distributing iron and steel at a figure which prevents users coming into our market to buy.

The Federation of British Industries has addressed the following series of questions to its affiliated associations with a request for a reply at the earliest moment. The reply is to help the Main Transport Committee

of the Federation in drawing up a considered case for the general reduction in railway rates and charges. (1) To what extent have you diverted traffic from railway to road or water transport? (2) What amount of such traffic diverted would you hand back to railways if rates were reduced to say, 75 per cent. above 1913 rates? (3) Can you give any idea of what increased tonnage, if any, would result from a reduction in railway rates to, say, 75 per cent. above 1913, apart from (2)? (4) To what extent are the prices of your commodities to-day in excess of an average pre-war price? (5) What percentage reduction from the existing rates is necessary to assist your business? (6) To what extent have the increased rates caused a limitation of distribution so far as your firm is concerned, *i.e.*, have you had to cease sending long distances? If so, please give a few instances. Would you increase revenue to railways by sending further distances, assuming a reduction, so that rates would be only 75 per cent. above 1913 rates?

The Secretary of the London Iron and Steel Exchange, Limited, states that the prices ruling to-day average about 40 per cent. over the pre-war level and the manufacturers urge that until the scale of costs of transport and other charges are again reduced it is unfair to ask for further price concessions. The recent action of the railway companies in reducing certain charges has not yet been followed by the recommissioning of many blast furnaces, but nevertheless there is a gradual increase, as shown above, in the number working, notwithstanding the steady reduction in prices of pig-iron. The situation ruling, however, is to the advantage of the British producer, as the French and Belgian makers of pig-iron are unable to deliver their material at consumers' works in this country at competitive prices. Unfortunately the foundry trade of this country is still suffering serious depression and this re-acts upon the demand for foundry pig-iron. There is a brisk demand from the home trade for semi-finished materials, and in this department also competition from overseas makers has practically ceased to trouble British works. How completely the situation has changed as regards this market is shown by the fact that instead of large quantities of foreign semi-finished material being imported there is an increasing volume of inquiry from continental buyers. The demand for finished steel articles has not yet assumed the proportions hoped for; but there are signs that prices have at last reached a level which is proving attractive to foreign consumers.

HEAVY DECLINE IN THE EXPORT OF TONNAGE FROM SWEDEN.—According to *Swedish Export*, there are various indications that the export of tonnage from Sweden is on the decline. Applications for licences to sell vessels abroad still occur, it is true, but somewhat sporadically, and they concern only one vessel here and there. During October such licence to export has been granted only for six vessels. Up to the beginning of November leave had been given to export shipping aggregating 99,588 tons, of which amount 95,311 tons were steamers.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—The second term at University College begins on Tuesday next, the 17th inst. The following are some of the public lectures to be given during the term:—"Industrial Unrest," by Mr. B. Seebohm Rowntree; "The Bridges of London," by Mr. A. T. Walmisley, M.Inst.C.E.; "The Preservation of Ancient Buildings," by Mr. A. R. Powys; "The University of London, its History, Present Resources and Future Possibilities," by the Provost, Sir Gregory Foster; and two lectures by Major-General Sir George Aston on "Some Principles of Amphibious Warfare" and "War History and its Application." A copy of the full programme may be obtained by sending a stamped addressed envelope to the Secretary, University College, London, W.C.1.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—For the purpose of commemorating the first meeting of the Society of Telegraph Engineers, which was held on February 28, 1872, the Council of the Institution of Electrical Engineers (originally the Society of Telegraph Engineers) are arranging for the following Institution functions to be held on dates approximately corresponding to that of the original meeting:—Tuesday, February 21, at 4 p.m.: Popular lecture (admission by ticket, a limited number of seats being reserved for guests), by Professor J. A. Fleming, F.R.S., on "Michael Faraday and the Foundations of Electrical Engineering." Same day, at 7 p.m. (for 7.30 p.m.): Annual dinner at the Hotel Cecil. Wednesday, February 22, at 8.30 p.m.: Professor Fleming will repeat his lecture of the previous day. On Thursday, February 23, from 4 p.m. to 6 p.m., and from 8 p.m. to 10 p.m., a number of members of the Institution and others closely connected with the early development of electrical engineering will give short discourses on their reminiscences and experiences during the early history of the electricity supply industry. The speakers will deal both with matters of scientific and technical interest and also with the effect of legislative action on the progress of the industry. Full particulars will be published later.

YEAR-BOOKS AND ANNUALS.

The Society of British Gas Industries' Directory, 1921.—We welcome the first issue of this directory, recently published by the Society of British Gas Industries, 6, Bond-court, Walbrook, E.C. 4. It measures 12 in. by 9½ in., and contains about 450 pages of information on the society, its members, firms, the products of the latter, on the British standard specifications relating to refractory materials, cast pipes, by-products, &c. Separate articles deal with the method of sampling and testing spent oxide, British standard conditions of contract, the Gas Regulation Act, 1920, and other subjects connected with gas. The book appeals to concerns connected with gas-making, to users of gas and also to engineers who have charge of gas installations. Copies can be obtained at the price of 21*s.* net from the offices of the society.

The South Wales Coal Annual, 1922.—This directory for the present year, the eighteenth year of issue, is edited by Messrs. C. P. Hailey and D. Willson Lloyd, and is published, at the price of 12*s.* 6*d.* net, by the Business Statistics Company, Limited, Baltic House, Cardiff. It will be found a most useful reference book by merchants and shippers who deal in South Wales coal, owing to the large amount of data it gives on contracts, prices, freights and other points. From the statistical point of view it will be no less useful by reason of its chapters on costs of production, tariffs, wages, tables of output, &c., and its diary of the principal events in the South Wales coalfield from January 1, 1920, down to July, 1921. It opens with a detailed index and is very clearly printed.

The British Journal Photographic Almanac.—For more than sixty years this almanack has been issued. The edition for 1922 contains an *epitome* of past progress in the art of photography as well as tested formulæ, tables, weights and measures, &c., for use in establishments where blue-printing and ordinary photography are aids to works routine or laboratory research. The book is issued by Messrs. Henry Greenwood and Co., Limited, 24, Wellington-street, London, W.C. 2, price 2*s.* in paper cover, or 3*s.* in cloth.

The Practical Electricians' Pocket Book and Diary, 1922.—The twenty-fourth edition of this little book, though generally similar to its predecessors, has been revised in many respects, certain sections entirely rewritten and additional chapters added. The latter deal with motor converters, current limiters, signalling apparatus on electric railways, and ignition, lighting and self-starting equipment for motor vehicles. The book is of the descriptive and instructive type rather than a compendium of tabulated matter, and is included in the list of books recommended for electrical installation work by the City and Guilds examiners. It is published by S. Rentell and Co., Limited, of Maiden-lane, Strand, London, at the price of 3*s.* net, and should prove useful to those who are engaged, not only in electrical work directly, but in the numerous industries in which a certain amount of electrical knowledge is now imperative.

Calvert's Mechanics' Almanack, 1922.—This handy publication for the current year, the forty-ninth year of issue, is edited by Messrs. Frank Nasmith and James McLachlan. It can be obtained at the price of 6*d.* net from Messrs. John Heywood, Limited, 20–22, St. Bride-street, E.C. 4. It gives tables of weights and measures, of squares, cubes, square and cube roots, and, in a comparatively small space, much information and many "wrinkles" which will be appreciated in workshop practice, and also by employers in charge at boiler houses and engine rooms.

Annuaire de la Houille Blanche Française.—This French annual, for the years 1921–22, the fifth edition, is edited by Mr. Auguste Pawlowski, in collaboration with a number of French engineers, and is published by the *Revue Générale de l'Electricité*, 12, Place de Laborde, Paris, 8. It contains a large amount of interesting information on the available water power throughout France and on its actual utilisation, and proposed further utilisation for a large variety of industrial purposes, including the electrification of the railways, notably the Paris-Lyons-Mediterranean system. Particulars are given concerning all the existing French hydro-electric companies, and metallurgical companies whose power is obtained hydraulically. The annual gives evidence of great activity on the part of French engineers and metallurgists in this most interesting field.

"*Ice and Cold Storage*" *Trades Directory*, 1922.—This directory, the present edition being the seventeenth, covers the cold storage, ice-making and refrigerating industries; it appeals not only to firms engaged directly in those industries but also to engineering concerns who manufacture the requisite apparatus and plant. It opens with tables giving the temperatures for the cold storage of a number of different articles, and many other figures bearing upon the industries in question, followed by information on recent patents granted, companies registered since November, 1920, the approved list of frozen meat stores, data on cold stores and ice factories arranged alphabetically according to towns, list of firms engaged in the said industries, list of vessels fitted with refrigerating machinery, &c. The price of the directory, bound in cloth, is 11*s.* 3*d.*, post free; it is published by Messrs. Iliffe and Sons, Limited, 20, Tudor-street, E.C. 4.

The Swedish Year Book, 1921.—We have received from Messrs. Williams and Norgate, 14, Henrietta-street, Covent Garden, W.C. 2, the London publishers, a copy of this year book, the first edition, which is issued by the A.-B. Svenska Teknologföreningens Förlag, Stockholm. It is in the English language, and since it gives detailed information not only on the agriculture, industries, mineral and other natural resources, but also on the people, the language, the administration of the country, it will be found both interesting and useful by a wide circle of readers. The chapter on mining gives figures of output of Swedish iron ore, the Swedish production of iron and steel, and states that in 1919 the country also produced 21·6 kg. of gold, 620·4 kg. of silver, 827 tons of lead, 3,558 tons of copper and 2,320 tons of zinc. The various industries are reviewed under foodstuffs, textiles, leather, wood, paper, &c. The book can be obtained at the price of 7*s.* 6*d.* net from the said London publishers. It measures 7¼ in. by 5¼ in., and contains 170 pages of subject-matter, maps, and illustrated advertisement sheets.

"*The Textile Recorder*" *Year Book*, 1922.—Although the textile trades and the manufacture of machinery for carrying them out constitute the main industries of many of our large cities and are a most important source of revenue to the country as a whole, little is known concerning them generally. For this reason, a compendium on these staple trades meets a real need. The year book of which this is a brief review, forms such a compendium; it is compiled and edited by Mr. Frank Nasmith and is issued at the price of 7*s.* 6*d.* net by Messrs. John Heywood, Limited, 20–22, St. Bride-street, London, E.C. 4, and Manchester. It measures 7¼ in. by 5 in., and contains over 650 pages of clearly-printed subject-matter covering the textile industries in all their various aspects, the information given being of the greatest value to manufacturers and merchants. Business men who, hitherto, may have been interested in the trades dealt with only occasionally will find the book of the greatest service for reference purposes; it will repay careful study by a wide circle, and we hope it will have a large circulation.

Almanacks and Calendars.—We have received the following since our last issue. Desk calendars from Messrs. Stewarts and Lloyds, Limited, pipe and tube manufacturers, Winchester House, Old Broad-street, E.C.2, and from The Lea Recorder Company, Limited, 28, Deansgate, Manchester.—A wall-calendar from Messrs. C. Isler and Co., Limited, artesian well engineers, Bear-lane, Southwark-street, S.E.1.—Monthly tear-off calendars from Messrs. Brown, Bayley's Steel Works, Limited, Sheffield, giving illustrated data on their stainless steel, and from The Brown Hoisting Machinery Company, Cleveland, Ohio.—Daily tear-off calendars from Messrs. the Milner Hurd's Patents Company, Limited, 4, Paradise-square, Sheffield, and from Messrs. Ashwell and Nesbit, Limited, engineers and iron-founders, Leicester.

"THE JOURNAL OF COMMERCE."—We have received a copy of the special annual issue of this journal, giving a review of shipping, shipbuilding, marine engineering, &c., during the past year. Its price is 3*s.* and by post 3*s.* 9*d.* The articles it contains have been contributed by correspondents of the journal and by a number of prominent engineers.

THE IRON AND STEEL INSTITUTE.—The annual meeting of the Institute is to take place on Thursday and Friday, May 4 and 5 next, at the house of the Institution of Civil Engineers. The annual dinner will be held on the evening of Thursday, May 4, at the Connaught Rooms, Great Queen-street, W.C. The secretary, in making this announcement, asks that the members who wish to take part in the next—thirteenth—International Geological Congress, to be held at Brussels in August next, should send in their names to him; he will supply further information concerning the organisation and arrangements as soon as this is available. The official language of the congress will be French, but papers and communications in English will be admissible.

ENGINEERS AND CHEMISTS.

*The Co-operation of the Engineer and Chemist in the Control of Plants and Processes.**

By G. M. GILL, of London, Member.

A GREAT need exists to-day for the supply of materials which have some pretence of being standardised, with quality, size and general characteristics much more uniform than is frequently the case with most manufactured commodities. With such variations in raw and other materials used for manufacturing purposes, it becomes a difficult problem to work plant and processes efficiently and in such a way as to produce articles of standard quality and quantity. As a result, great loss is caused to the country's trade and industry generally.

It is proposed in this paper to deal specifically with coal and refractory materials, and to outline a system which has been applied with the object of standardising the quality of gas. The South Metropolitan Gas Company being a user of coal to the extent of 1,250,000 tons per annum, has found it desirable to establish a fully-equipped laboratory and inspecting staff at Newcastle-on-Tyne, for the purpose of examining coals supplied to the company. The coal is sampled as it is loaded into the company's ships, after which the samples are analysed, and all coal above a definite size is hand-picked free from dirt, the results being telegraphed to London in time to give those responsible for the operation of the works an opportunity of regulating the carbonising plant to suit the varying grades of coal before its arrival. This system is still in its infancy, but excellent results are anticipated not only from the point of view of better-informed buying, but also of improvement in the cleaning of coals, and in the working of plant to suit each consignment of coal. One of this company's stations has already instituted a system of carbonising by which automatic adjustments are made varying with the volatile content in each consignment of coal. It should here be explained that in good carbonising from 90 per cent. to 95 per cent. of the volatile content in the coal is converted into gas and liquid products, and as the percentage of volatile matter in the coals used varies from, say, 24 to 34, it will be realised that the one class of coal needs very different treatment from the other, though it is a factor which has hitherto been neglected in gas works practice owing to lack of information.

The author has summarised the results of these tests in the case of four typical coals, which are fairly representative of a larger number similarly examined. These results are given in detail in Figs. 1 to 4 on this page.

The author claims to have no practical knowledge of coal mining, and cannot therefore give any indication of the limits of quality within which coals could be supplied. The diagrams at any rate show the variation in quality of coals actually being supplied, from the study of which it must be evident to practical users that considerable alterations in the regulation of plant are inevitable when coal so variable in quality is in daily use.

In gas works generally the class of coal in use is varying in some cases from hour to hour, and in others from day to day, and as consignments of coal differ so largely it is not customary to alter the regulation of plant until some time after a fresh class of coal has been in use and its effect has become apparent to those in charge. This change is generally too late for full advantage to be taken of the characteristics of the coal, but if this could be done before a commencement is made on a fresh class of coal much benefit would be derived. At the present time the name of a coal is the only indication of its quality and characteristics, but as will be seen from the diagrams, each coal varies so largely that the name is little indication of its quality.

Coal is everywhere bought not by quality but by name, and its price varies with the general reputation of the name in question, but these diagrams serve to show that there is so wide a variation in the quality of each coal that the worst cargoes of a so-called first-class coal are inferior to the best of a second class coal. There is, in fact, a large element of chance in regard to the quality of any particular consignment.

The author would suggest that the time has arrived when each colliery should grade or classify the coals from the various pits and seams, keeping each grade of the same quality within the narrowest practical limits. The advantages of such a step to the users would be very great, and this would react favourably upon the whole coal industry. To a gas undertaking it would result in higher yields of gas and products per ton of coal and per

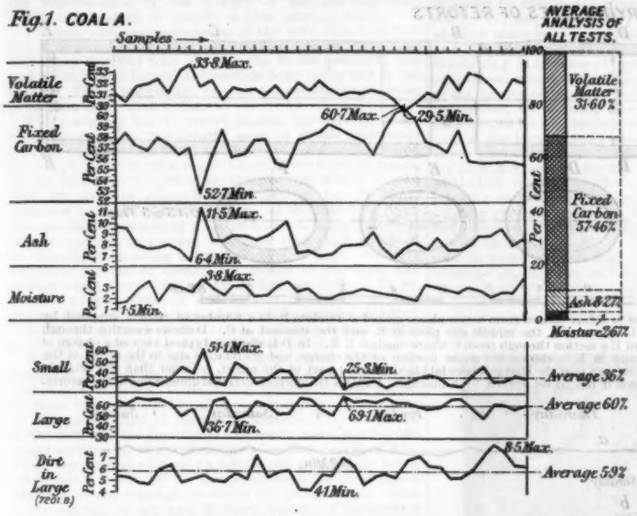


FIG. 1 shows the results of the examination of samples of Coal A, each sample being representative of a consignment of about 1,000 tons. The figures are calculated upon the wet bases, while the figures for "Fixed Carbon" are free from ash. The lower portion of the diagram shows the relative proportion of small and large in each sample, while the bottom line indicates the percentage of dirt hand-picked from the "large" portion of the sample, this latter giving a good indication of the efficiency with which the particular coal was hand-picked on the picking belts at the colliery. It will be noticed that in the case of six samples the percentage of dirt in the "large" portion of the coal amounted to over 7 per cent., which indicates very bad work on the part of those responsible for picking out this dirt.

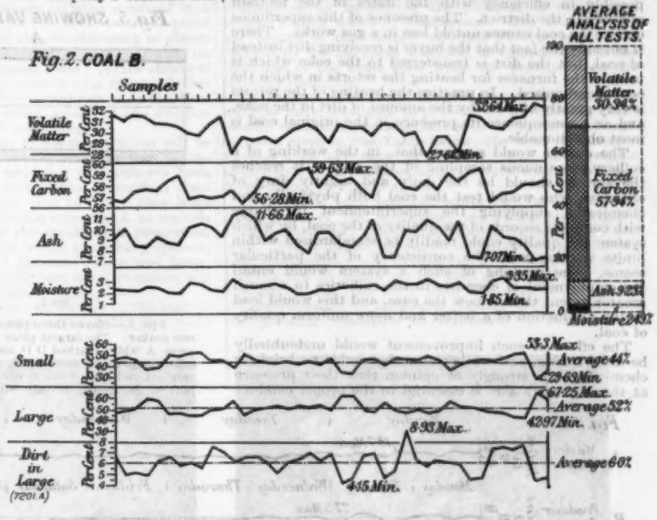


FIG. 2.—As in the case of Coal A, seven of the samples of Coal B contained over 7 per cent. of dirt in the "large" portion of the coal, which again emphasises the possibility of improvement in the quality of coal as a result of more careful picking. It will be noticed that the consignments with the lowest percentages of ash had generally the lowest percentages of dirt in the "large" portion of the coal, showing the extent to which this removable impurity affects the ash content.

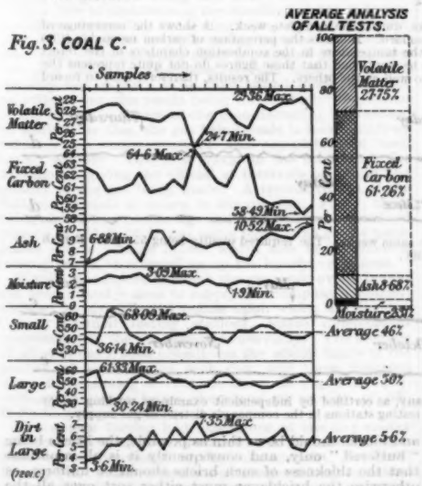


FIG. 3.—It will be noticed that Coal C contains more "Fixed Carbon" and less volatile matter than Coals A and B, rendering it more valuable for coke-making and less valuable for gas-making than Coals A and B. It will be seen that the percentage of volatile matter varies from 24·7 to 29·8, or 16·6 per cent. based upon the average of 27·7 per cent., and as the amount of gas contained in the coal depends upon this portion of the coal, it will readily be appreciated that a variation of this amount will interfere very greatly with the output of a gas-making plant. In this case only one consignment contained over 7 per cent. of dirt in the "large" portion of the coal.

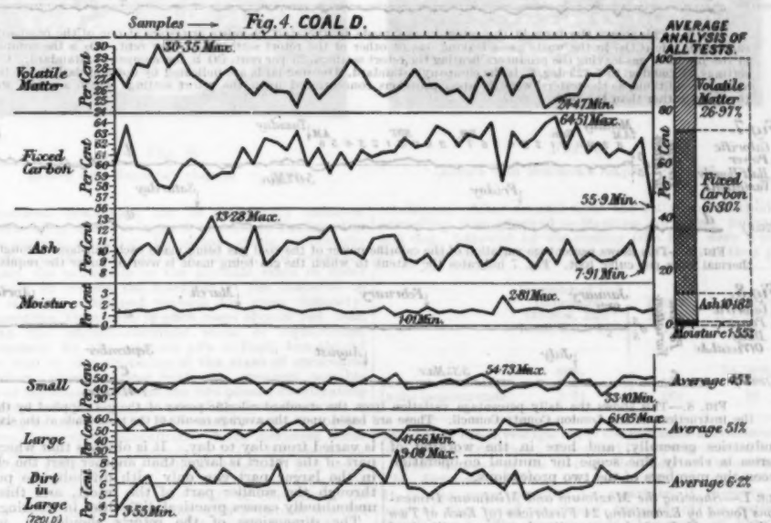


FIG. 4.—Coal D has the same general characteristics as Coal C, and might be termed a coke-making coal but for its high ash content. In this case 13 consignments contained over 7 per cent. of dirt in the "large" portion of the coal, while the variation in the percentage of volatile matter is even more marked than is the case in Coal C.

* Paper read at the Joint Meeting of the Institution of Mechanical Engineers with the Society of Chemical Industry, held on Friday, January 6, 1922.

unit of plant, a higher output per man, and a smaller variation in the quality of gas made, and these would have the effect of reducing the price of gas. The desired improvement would be much nearer achievement if the coal were picked more efficiently and consistently, though, of course, this is not the whole of the problem.

In examining the samples of coal, these are screened through a sieve with holes ¼ in. square, and the coarse portion not passing through is hand-picked free from dirt, the quantitites of which dirt are shown in the diagrams. A study of these figures makes it quite clear that the picking process at the pits is a haphazard one, varying possibly in efficiency with the dates of the football matches in the district. The presence of this superfluous dirt in the coal causes untold loss in a gas works. There is not only the fact that the buyer is receiving dirt instead of coal, but the dirt is transferred to the coke which is used in the furnaces for heating the retorts in which the coal is carbonised. In practice the heating of the retorts is very greatly affected by the amount of dirt in the coke, and as a consequence its presence in the original coal is most objectionable.

The author would suggest that, in the working of a colliery, continuous sampling of the coal as it reaches the surface should be the daily and nightly duty of chemists, who would test the coal both physically and chemically, supplying the superintendent in charge with complete records of the quality of the coal, by which system the quality could readily be standardised within limits varying with the consistency of the particular seams. The working of such a system would entail the employment of chemists in the collieries to a much greater extent than is now the case, and this would lead to the production of a better and more uniform quality of coal.

The effect of such improvement would undoubtedly be far reaching, and while the author holds no brief for chemists, he is strongly of opinion that their presence at the engineer's side is essential to the proper conduct of industries generally, and here in the working of collieries is clearly fine scope for mutual co-operation between the members of the two professions.

TABLE I.—*Showing the Maximum and Minimum Dimensions found by Examining 24 Firebricks (of Each of Two well-known Makers) chosen at Random from a Stack of such Bricks. The Correct Dimensions should be 9 × 4·5 × 3 in.*

——	Length.	Breadth.	Thickness.
Maker (A)—	in.	in.	in.
Maximum	9·30	4·56	3·16
Minimum	9·01	4·40	2·90
Difference	0·29	0·16	0·26
Maker (B)—			
Maximum	9·35	4·5	3·12
Minimum	8·92	4·27	2·87
Difference	0·43	0·23	0·25

Refractories.—The variation in size and quality of firebricks and blocks and retorts is one of the most unsatisfactory features with which users of refractories have to contend. All kinds of difficult problems have to be faced for want of uniformity in this respect. Table I shows the varying length, width and thickness of firebricks supplied by two well-known makers in this country.

Fig. 5 shows three pieces of retort which were picked out from seven pieces chosen at random from a quantity in stock supplied by a well-known manufacturer. These three pieces have been placed together to make up the usual length of a 20-ft. retort. The internal dimensions of these pieces should have been 22 in. by 15½ in. of an oval section, as shown in Fig. 5. Actually the dimensions in the 20-ft. length vary from 22·50 in. to 21·68 in. wide, and from 15·50 in. to 15·31 in. in height. As used in a gas works these retorts are charged with coal and when coked the appearance is as shown in Fig. 5. The charge of coke has then to be pushed out at one side, and in some cases the direction in which it is pushed is varied from day to day. It is obvious that where one part of the retort is larger than another part the charge in the larger part can only with difficulty be pushed through the smaller part of the retort, and this fact undoubtedly causes practical difficulties in working.

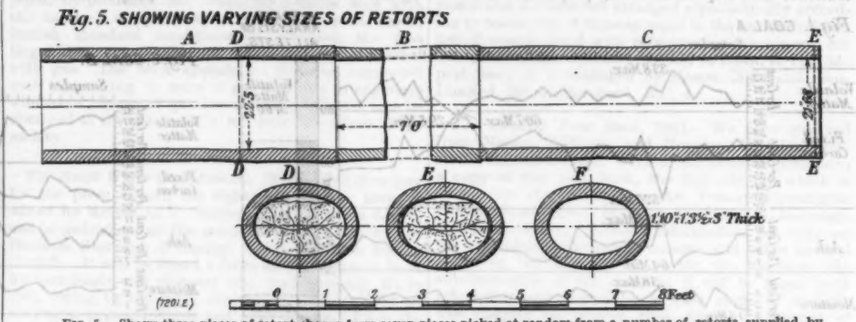


FIG. 5.—Shows three pieces of retort chosen from seven pieces picked at random from a number of retorts supplied by one maker. The largest piece is shown at A, the middle size piece at B, and the smallest at C. D shows a section through piece A where marked D D, and E a section through piece C where marked E E. In D is shown a typical view of a charge of coke ready to be discharged, and in E is shown the same portion of the charge and its relative size to the retort at the smallest end from which it will be seen that the charge where laid in the largest part of the retort, is larger than the smallest part of the retort, through which it has to be pushed by a machine. F shows the correct sectional dimensions of the retorts.

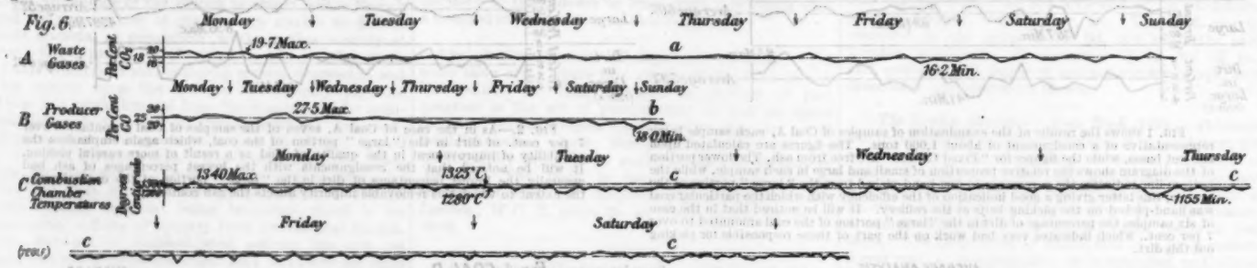


FIG. 6.—This shows the tests in the retort-houses made by the staff chemists or testers at one of the company's works, during one complete week. A shows the percentage of carbon dioxide (CO_2) in the waste gases leaving one or other of the retort settings. 18 per cent. CO_2 is the company's standard. B shows the percentage of carbon monoxide (CO) in the producer gas leaving the producers heating the retort settings. 25 per cent. CO is the company's standard. C shows the temperature in the combustion chambers of the retort settings. 1,280 deg. to 1,325 deg. C. is the company's standard. The standards are indicated by dot and dash lines. It should be mentioned that these figures do not quite represent the average conditions, as the testers' work is upon occasions concentrated upon the retort settings which are not working so well as the others. The results, therefore, tend to record the worst rather than the best.

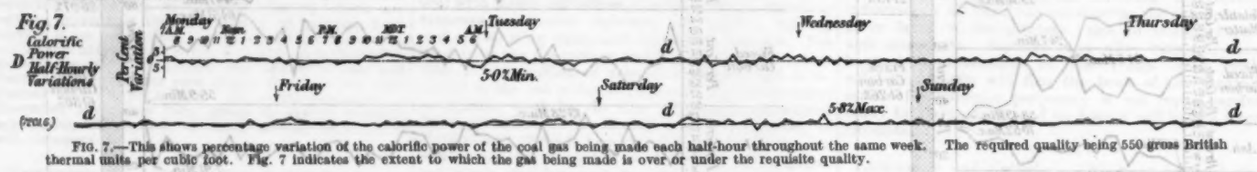


FIG. 7.—This shows percentage variation of the calorific power of the coal gas being made each half-hour throughout the same week. The required quality being 550 gross British thermal units per cubic foot. Fig. 7 indicates the extent to which the gas being made is over or under the requisite quality.

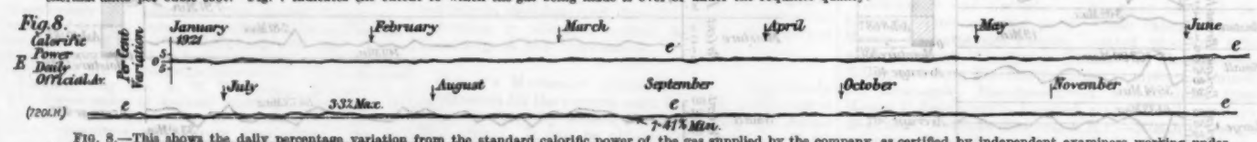


FIG. 8.—This shows the daily percentage variation from the standard calorific power of the gas supplied by the company, as certified by independent examiners working under the instructions of the London County Council. These are based upon the average results of the tests made at the six official testing stations in the company's district of gas supply.

The dimensions of the retorts should be, within practical limits, the same from end to end, both internally and externally. The internal dimensions affect the discharging operations and the external dimensions affect the building of the settings, a large amount of cutting of bricks and blocks being necessary where the retort is of a bad shape. Unfortunately where the shape of the material is bad, human nature being what it is, the workmanship is also frequently bad, the difficulties of the retort setter being so much increased by the faulty shape of the retorts.

Such variations are typical of material supplied by most of the firebrick makers in this country, and the author has no hesitation in asserting that it is high time that firebrick makers started to employ rational methods in the control of the ingredients used in brickmaking, and of their mixing, drying and burning. The variation in size is doubtless due to faults in one or other of these parts of the process, such faults being allowed to develop in the course of manufacture owing to a complete absence in most firebrick works of any semblance of scientific control.

In visiting a firebrick works, one is usually told that the important work of controlling the kilns is left in the hands of a workman upon whose judgment, without the aid of instruments, depends the degree and uniformity of the temperature and the period over which it is extended. The same is true of the choice and mixing of the raw materials from which the bricks are made. To anyone accustomed to the aid which is given by chemists and others whose duties consist of keeping a regular check upon all the factors which contribute to the maintenance of uniformity in the quality of manufactured commodities, it is of course obvious that the absence of this absolutely necessary assistance can but result in the defects of which mention has been made.

In the building of any structure of refractory materials it is hightly important that the joints between bricks and blocks should be as thin as possible, the bricks being "buttered" only, and consequently it is all-important that the thickness of such bricks should be uniform, as otherwise the bricklayer must either sort over all the bricks to get those of a similar thickness to lay in one course, or he must increase the thickness of the joint wherever the thin bricks are laid. In either case the remedy is very objectionable. Here again there is scope for the chemist to work in conjunction with the engineer or manufacturer.

What appears to the author to be necessary in the conduct of firebrick works is the institution of methods providing for :—

(1) The continuous sampling and analyses of mixtures in use, both chemical and physical.
(2) The use of heat recorders in kilns.
(3) Definite limiting standards for size and shape.
(4) Guaranteed working to specifications.

It might be argued that the extra cost of applying such methods would not be forthcoming from the sale of the materials made, or, in other words, that the bricks would be too expensive to sell. It is suggested that the contrary result would be experienced.

The control proposed would doubtless result in the production of a higher and more consistent quality of brick; this would increase sales and consequently lower overhead charges in the works. The control would further diminish rejected bricks, save fuel costs in kilns, increase capacity of plant and effect improvements which would result from increased knowledge of the process. At present the most enlightened refractory

users are searching the country for a better quality of materials, which is of far greater importance than that of price, important though that be.

Refractory users are hopeful, though not confident, that they may find what they require in this country. They do not want to go abroad for their materials, and if this course has to be taken it will be because they have been driven to it by the apathy of the British refractory manufacturer.

Control of Plant for Making Standard Gas.—The South Metropolitan Gas Company has applied scientific control both to the working of the manufacturing plant and to the maintenance of the quality of the gas supplied, which is standard in quality within narrow limits.

To start with the carbonising of the coal, this is carried out in retort houses where the coal is placed in retorts and there distilled into gas and the liquid products, tar and ammoniacal liquor, the residue coke being left in the retort. These retorts are heated by producer gas from producers fired with coke.

The company has 17 retort houses, the average size of which contains 246 retorts, each of which carbonises 25 cwt. of coal per 24 hours. Sixteen retorts are heated by one producer consuming 3·7 tons of coke per 24 hours. If coal and coke are priced at 30*s.* per ton, it will be seen that the average retort-house is dealing per 24 hours with raw material valued at 546*l.* If the other expenditure entailed in working a retort-house is added, such as labour, upkeep, and power, a further 168*l.* must be added to this figure, making a total of 714*l.* a day. A fairly complete system of control by means of chemists and testers can be provided at an additional cost of 3*l.* 8*s.* per 24 hours. Does it not appear obvious that this expenditure—0·5 per cent. of the whole amount involved—is likely to be recouped many times over as a result of the more intelligent working of the plant?

Fig. 6 gives the results of all tests made during one complete 7-day week in three retort-houses at one of the company's stations, these being typical of the whole. In these tests the quality of the producer gas is indicated by the percentage of carbon monoxide (CO) contained in the gas, and the quality of the waste gases leaving the retort settings by the percentage of carbon dioxide (CO_2), while the degree of heat to which the retorts are being subjected is shown by the temperature in the combustion chamber of the settings, in which the producer gas meets a hot supply of air and is there burnt. Considerable variations are shown in all these figures, this emphasising the importance of carrying out such tests, which enables faults to be remedied as soon as disclosed. It is quite certain that were rule-of-thumb methods allowed to replace the control system, the variations would be much wider.

As explained above, the South Metropolitan Gas Company has adopted a policy of supplying a standard quality of gas, this being 550 B.Th.U. per cubic foot. With a view to maintaining the standard and to reducing variations in quality to a minimum, a typical system in use at one of the manufacturing stations may here be described. The gas being made is collected at a uniform rate in a small test gasholder for each hour throughout the day and night. It is then tested every hour for calorific power, the result being immediately telephoned to the official in charge of the manufacturing operations. In addition to this, the gas being made is tested midway between the commencement and completion of each hourly sample. This is a check on the other test, the two figures giving the official at intervals of ½ hour the quality of the gas being made. A typical record of the half-hourly tests is shown in the diagram, Fig. 7, these being shown as a percentage above or below the standard quality of 550 B.Th.U. per cubic foot. The gas as made passes into a storage holder which acts as an efficient mixing vessel, thus levelling up the hourly variations.

Finally, the holder in which the gas made over a period has been mixed is used to supply the company's district, situated at six different points upon which are London County Council testing stations, where independent examiners test the gas several times daily. The average of all such daily tests constitutes the official figure of the quality of gas supplied each day, and those reported since the beginning of 1921 are shown in Fig. 8 as a percentage above or below the standard quality of 550 B.Th.U. per cubic foot.

The author having had experience of the day-to-day collaboration with a well-constituted chemical department under the control of the chief chemist, Mr. E. V. Evans, F.I.C., has no hesitation in recommending others concerned with the manufacture of any commodity, to do all in their power to obtain similar assistance. These standardising methods were originated a number of years ago, and there is not the slightest doubt in the author's opinion that by the adoption of similar methods the stability and prosperity of any manufacturing business can be greatly improved.

IRRIGATION IN QUEENSLAND.—It is reported that good progress has now been made with an irrigation scheme in the Inkerman district of Queensland, and estimated to cost 400,000*l.*, of which about half the money has already been spent. So far 120 wells have been sunk, of which 50 have been tested, and 23 found to be defective owing mainly to the strata. The total available acreage for irrigation under the present scheme is 10,500, but 57,000 acres are in the gazetted boundary. The scheme, which is under Government control, is expected to be completed in four year's time. Speaking generally, Queensland is watered by numerous permanent rivers and creeks, while in the western portions of the State there are several thousand sub-artesian and artesian bores, which provide a superabundance of water for stock. The presence of such immense supplies emphasises the unlimited possibilities of irrigation on a large scale in the near future.

THE STUDY OF COALESCENCE IN STEELS, AND ITS COMMERCIAL RESULTS.*

By ALBERT PORTEVIN and VICTOR BERNARD (Paris).

(*Concluded from page* 31.)

PART II.—INFLUENCE OF THE COALESCENCE OF CEMENTITE ON THE PROPERTIES AND HEAT TREATMENT OF HYPEREUTECTIC STEELS.

The inquiry will now be directed briefly and successively to the influence on coalescence of:—(1) The hardness, in order to obtain the maximum softness required in a steel; (2) the malleability, in the cold, from the point of view more particularly, of the die-stamping of sheets and the drawing of tubes; (3) the surface finish on machining, in the case of precision parts; (4) the chemical properties, which will consist merely of a recapitulation of the results obtained by other observers; (5) the heat treatment, by showing the reflex action of the original coalescence on the results of quenching.

It is the last-named section to which attention will be more particularly directed, seeing that, so far as the authors are aware, hardly anything has hitherto been published respecting the experimental numerical data relating to this subject except that to which they have already given publicity†. On the other hand, as regards the effect of coalescence on the mechanical properties, reference can be made to the works previously quoted, and in particular to that of Belaiew, Howe and Levy, Hanemann, Morawe and Lindt, and mere mention will be made of the present authors' own results.

1. *Influence of the Hardness.*—Although in the case of many steels such softening as is required for their easy

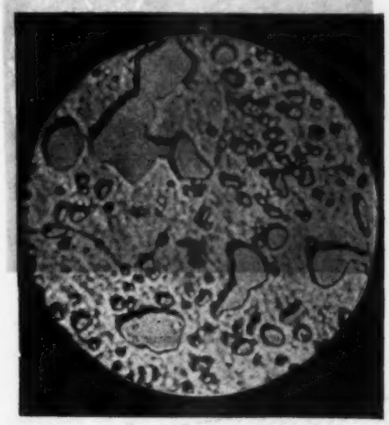


FIG. 8.

Etched with Benedick's reagent. × 1200.

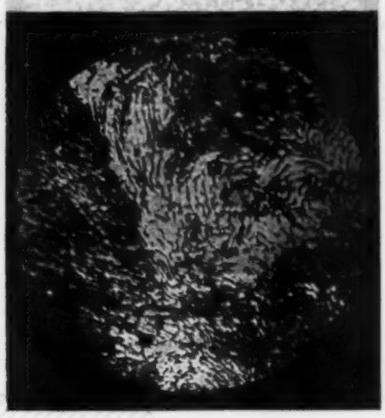


FIG. 9.

Etched with Benedick's reagent. × 1200.

and economic machining can be sufficiently obtained by an annealing which brings the pearlite to the lamellar or even sorbitic condition, for certain steels, specifically hard owing to their chemical composition, it is necessary to obtain the cementite in the globular state in order sufficiently to reduce the hardness of the material to enable it to be machined without too great difficulty. The annealing treatment in such cases should not lead only to the physico-chemical state of equilibrium characterised by the mixture $\alpha Fe + Fe_3C$, but should further lead to the obtaining of the state of structural equilibrium corresponding with the greatest possible degree of separation between the two phases constituting this mixture. This is an annealing for structure, a coalescing anneal to which Howe and Levy have applied the term "divorcing annealing." Such instances occur industrially in, more particularly:—(*a*) Hypereutectic carbon tool steels with or without chromium and tungsten; (*b*) ball-bearing steels with 1·0 per cent. of carbon and 1·0 per cent. to 2·0 per cent. of chromium, for which a softening corresponding with a Brinell number of 187 to 170 is required (imprint diameter of 4·4 mm. to 4·6 mm. with a 10 mm. ball and a pressure of 3,000 kg.). So low a hardness cannot be obtained in a steel of such a composition except by causing the cementite to coalesce. The resultant softening is naturally a function of the degree of coalescence acquired by the cementite elements. The more marked the ferrite-cementite separation, or, in other words, the more the cementite globules are developed, the lower the hardness. It would obviously be of great interest to be able to define numerically the average size of the cementite elements, so as to be able to define the degree of coalescence attained in a given steel containing a known proportion of cementite. An attempt might be made, with this object, to count the globules per unit volume of steel. By ascertaining the number, *n*, of elements per unit of surface, in a micrographic preparation, the number per unit of volume would be given by $N = n^{\frac{3}{2}}$. In the micrographic estimation, however, it would be necessary to have recourse to very high magnifications (× 1,000) in order to be able to count the element visible in the globular pearlite, which would only be possible in a reduced section, and this would so falsify the result that the probable error would increase enormously. For the moment the authors cannot help regarding such a process of estimation as of questionable value. It appears to them better, for the attainment of the end in view, indirectly to estimate the degree of coalescence by measuring the physical or mechanical property with which it corresponds. For this purpose the degree of coalescence attained will be regarded as defined by the hardness attained, as compared with the hardness of the same steel when the pearlite is in the lamellar condition.

In carbon tool steels the maximum softening the authors have been able to produce by industrially practicable treatments corresponds with the hardness characteristics given in the Table below, the steel in question having 0·98 per cent. of carbon. The micrographic appearance in both states is given at a magnification of 1,200 diam., in Figs. 8 and 9.

It has thus been possible, simply by influencing the coalescence of the cementite, to reduce the original Brinell hardness and the breaking stress by 50 per cent. These results have been obtained by the following heat treatments:—(*a*) Coalescing, or structural anneal; heating for 25 hours at 750 deg.; cooling* at, on an average, 5 deg. per hour from 750 deg. to 650 deg.; (*b*) regenerating, or structural-refining anneal to induce the globular condition to transform to the lamellar condition. After several tests the following method of annealing was adopted:—Heating for three hours at 850 deg., followed by air cooling (the bars were 8 mm. to 25 mm. in diameter). It was from samples thus prepared that the investigation of the influence of coalescence on the heat treatment (described later) was carried out.

——	Diameter of Ball Impression. (10-mm. Ball; Load, 3,000 kg.).	Brinell No. Δ.	Value of $R = 0{\cdot}34\,\Delta$.
	mm.		kg./mm.²
In the globular state	5·1	137	47
In the lamellar state	3·75	262	89

Note relating to the Brinell Hardness of Cementite.—The Brinell hardness of cementite is not known. It is not even possible to ascertain it directly, by any of the usual methods, because of its extreme brittleness.† The investigation, however, of the products of coalescence furnish a method of ascertaining it indirectly by extrapolation, from the following considerations. It is known that, in the binary alloys formed of a mixture in variable proportions, of two similar constituents, the hardness is practically a linear function of the composition when the structural elements remain constant in size. Therefore, if the proportions of the constituents remain constant the hardness will tend to increase as the fineness of the structural elements. The iron-carbon alloys in the annealed state consist of two phases, Fe, and Fe_3C, intermingled, but the structural elements of which these phases are composed may vary very considerably in size according as they do or do not form part of the eutectic pearlite in its lamellar form. This lamellar pearlite forms a definite aggregate with 9 per cent. of carbon and a Brinell hardness in the neighbourhood of 250.

According to the rule just enunciated, the Brinell

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* Paper read before the Paris meeting of the Iron and Steel Institute, September 6, 1921.

† A. Portevin and V. Bernard, Journal of the Iron and Steel Institute, 1914, No. II, p. 204. Quite recently Dejean (*Technique Moderne*, 1920, vol. xii, page 403), dealing with the subject, confines himself to instancing this effect of coalescence on the hardening, merely as an inductive result of industrial practice.

* This was applied, in ordinary practice, to a mass of metal weighing 5 tons.

† Its hardness on the Mohs scale is similarly unknown, the values given varying, according to the method of testing, up to 100 per cent.

hardness of iron-carbon alloys, starting with pure iron and going up to 6·60 per cent. of cementite in the annealed state, can be represented schematically (in terms of the carbon percentages, as follows (Fig. 12). (*a*) For the products containing pearlite in the lamellar state, by two straight lines, FP and PC, connecting the points indicative of the hardness of pure iron (point F), of lamellar pearlite (point P), and of the cementite (point C); (*b*) for the coalesced products in such a manner as to connect all the cementite elements in globular form, and of the same order of size, by a straight line of minimum hardness, FC; (*c*) for the products containing the whole of their carbon in the sorbitic state by an ill-defined curve, FSC, relating to the maximum hardness in the annealed state.

The hardness in the annealed state can therefore display the whole of the values comprised within the field FSCF, according to the carbon percentage and the state of division of the structural elements, and the hardness of the cementite can therefore be ascertained by either of two methods:—(*a*) By plotting the points of the line PC of the hardness of the hypereutectic products containing pearlite exclusively in the lamellar conditions, a condition extremely difficult to realise in the case of cast iron, as either sorbite and troostite, or of certain sheets, and by means of micrographic examination, that the sheets giving unsatisfactory results possessed a structure more or less partly lamellar (sheets of 3 mm. thick). Comparative tensile tests carried out on the same steels in the globular and lamellar conditions respectively, the latter being obtained by appropriate annealing, have given the following figures for the mechanical properties.

Samples.	State.	R.	E.	Elongation.
		(kg./mm.²).	(kg./mm.²).	per cent.
I.	Globular ..	38·2	21·3	32·3
	Lamellar ..	43·3	28·2	30·2
II.	Globular ..	39·6	21·3	33·8
	Lamellar ..	42·1	28·6	32·0
III.	Globular ..	37·6	22·6	33·5
	Lamellar ..	41·7	28·2	33·0
IV.	Globular ..	43·2	23·0	32·0
	Lamellar ..	46·9	30·0	29·0

These results show that the most marked difference occur in the comparative properties of the same sheet, particularly as regards the elastic properties. This leads to the conclusion that the advantages possessed by using sheets with a globular structure for die-stamping reside chiefly in the fact that the work required to effect a given deformation (such as OD, Fig. 13) is distinctly lower than that which would be necessary in the case of a sheet, the structure of which was lamellar. Previously it might, *a priori*, have been thought that the advantage of using such sheets was that their coefficient of elongation was so much greater that more work could be put upon them without risk of cracking. An examination of Fig. 2 also shows that in the case of the sheet with a globular structure the margin of safety between the elastic limit and the breaking stress is larger than it is in the case of those with a lamellar structure (compare the differences between the ordinates E_1R_1 and E_2R_2).

3. *Influence of the Surface Finish after Machining.*—The globular structure would appear to be the normal structure for eutectic and hypereutectic carbon tool steels, owing to the facilities they offer for machining. The authors have, however, had occasion to note an instance wherein this structure required to be destroyed, by means of an appropriate anneal, in order to give workshop satisfaction. It was a case of making screw plugs of great accuracy. When certain steels were used the faces of the threads were roughened to an extent incompatible with the degree of finish required, whereas with other bars of the same steel the faces of the threads were perfectly smooth. The microstructure of the steels giving the defective threading is shown in micrographs Figs. 10 and 11, these being to a magnification of 530 diameters. This, then, was a case where the globular structure gave rise to difficulties in machining, these difficulties being surmounted by destroying this structure by annealing at 850 deg. followed by air cooling. After this treatment the bars reverted to the lamellar state, and the appearance of the threads became satisfactory.

4. *Influence on the Chemical Properties.*—Coalescence, by modifying the shape and size of the structural elements, reacts on the susceptibility of the steel to chemical reagents. No experiments have been made by the authors in this connection, and they will confine themselves to recalling the experiments of Whiteley, and of Hanemann and Lindt. The latter showed that coalescence causes the sulphuric acid solubility of steel to decrease, and the former has shown that the values found by the Eggertz colour carbon test are considerably raised by coalescence.

5. *Influence on the Heat Treatments.*—Coalescence in steels is, as has been said, a result of the unequal intersolubility of the various structural elements of the complex, a Fe + Fe_3C. As, therefore, the phenomenon is a manifestation of a tendency towards a state of structural equilibrium, it ought to follow that the intersolubility of the structural elements as a whole will diminish and tend towards a minimum. Besides this, and without bringing into consideration the variation in solubility resulting from the modification of the radius of curvature,

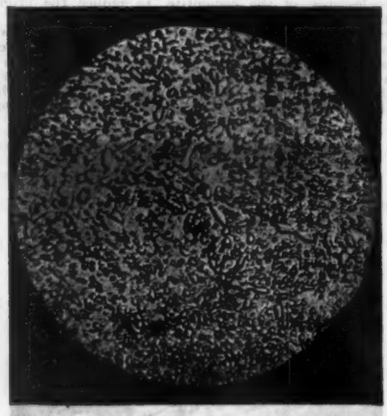

FIG. 10.

Etched with Benedick's reagent. × 530.

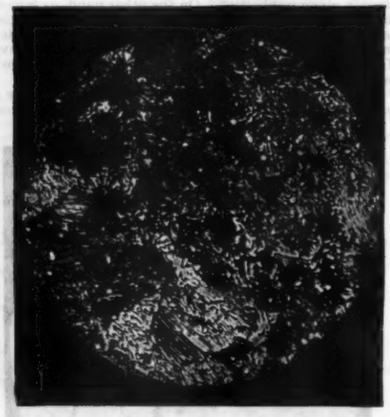

FIG. 11.

Etched with Benedick's reagent. × 530.

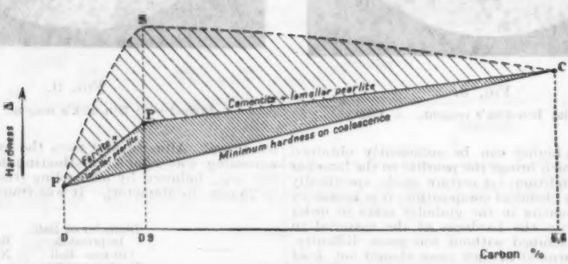

FIG. 12.

Schematic Representation of Brinell Hardness.

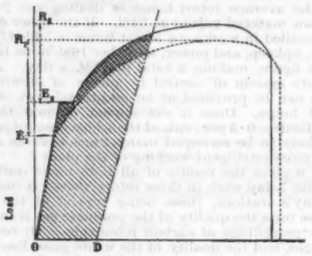

FIG. 13.

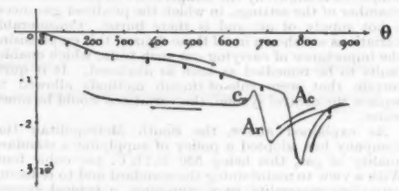

FIG. 14.

Differential Dilatometer Curves of an Eutectic Coalesced Steel. On cooling premature precipitation of cementite takes place (above Ar there is a region of high dilatation). Interval of tests, five minutes.

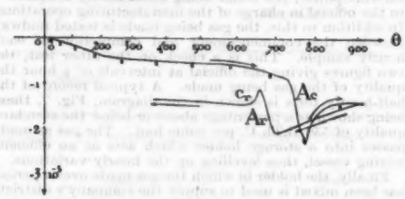

FIG. 15.

Dilatometric Differential Curves of the same steel, annealed, and with lamellar structure. On cooling the dilatation is normal above Ar. Interval of tests, five minutes.

globular pearlite, are always intermixed with the lamellar pearlite; (*b*) by plotting the points of the line FC of minimum hardness for various steels and cast irons, the minimum hardness of which has been estimated by their coalescence.

The latter process is practicable. By taking the only value quoted, that for the steel containing 0·98 per cent. of carbon, we arrive at a result of about 400 for Brinell hardness of cementite but, naturally, in order to attain a reasonably accurate result, a whole series of points ought to be determined along the line FC at regular intervals up to about 5 per cent. of carbon.

2. *Influence on the Malleability in the Cold.*—As coalescence leads to a lowering of the apparent elastic limit and an increase in the elongation prior to fracture it facilitates the deformation of the metal, a result of great value in operations where this property is sought, as in the die-stamping of sheet metal and in tube drawing.* Indeed, the effect of all such methods of manufacture as comprise alternations of cold-working and annealing is, as has already been seen, to stimulate granulation of the cementite if the heat treatment be rationally carried out. The authors have been able to ascertain, in connection with difficulties encountered, in the manufacture of war materials, from the stamping

* There may be recalled, in this connection, the properties of damascene steel (Belaiew); the influence of coalescence on the increase in the number of alternating areas prior to rupture in steel wire (Hanemann and Lindt), and the malleability of certain thin strands of high carbon and coalesced steels described by Hanemann and Morawe.

the rate of mutual intersolubility of the ferrite and of the cementite diminishes owing to the reduction of the contact surfaces*. For these different reasons the dissolution of the carbide on heating will be more difficult to obtain in these coalesced steels. This is of extreme importance from the point of view of hardening as the heat treatments thus appear to be functions not only of the chemical composition of the steel, but also of its initial structural state, and therefore of its previous heat treatment.

The authors have already shown† that in order to obtain the same mechanical results with the same hardening treatment, it is necessary notably to prolong the period of heating in the case of steels already coalesced. They propose, on this occasion, to examine once again the influence of coalescence on the solution of iron carbide, on heating, by comparing one and the same steel in the globular state, and in the lamellar state. With this object they have had recourse to the following methods:—(*a*) Direct methods by the quantitative investigation of the curves of heating and cooling plotted by the methods in use for the determination of the critical points of steel, and using, more particularly,

* If a lamella of cementite of e thickness and $l \times l$ dimensions splits up into n spheres of equivalent volume, the variation in the resultant surface is diminished in the ratio:

$$\frac{s}{S} = 2 \cdot 4 \left(n \frac{e^2}{l^2} \right)^{\frac{1}{3}}$$

† Journal of the Iron and Steel Institute, 1914, No. II, p. 204.

the thermal and differential dilatometrical methods; (b) indirect processes, by comparing the effects of heat treatments on the same steel in two different structural states, globular and lamellar, a comparison carried out in respect of their hardness, microstructure, electrical resistance and magnetic properties.

Thermal Method.—As it was a question of bringing into evidence very slight variations in the solubility of the carbide, the Roberts-Austen differential method was adopted. As is well known, in the case of these differential thermal curves the amplitude of the isothermal anomaly, due to the A1 transformation, can serve as a measure of the amount of heat evolved or absorbed in this transformation*, and therefore, as in the present instance, of the amount of carbide taken into solution or liberated therefrom. In order, however, that this method may lend itself to quantitative estimation it is necessary to eliminate a series of causes of error and of experimental difficulties, and this the authors have done by adopting the arrangements they have already described elsewhere†. They have, besides, in order to ensure the comparability of the thermal conditions, limited themselves to the examination of the effect of successive heatings on the same sample, initially coalesced, without the slightest derangement of the differential apparatus. Despite all these precautions the thermal method has only yielded very minute differences, and has not therefore commended itself to the authors as a suitable method to bring out variations in the carbide solubility. For this purpose it is, indeed, distinctly inferior to the method hereinafter described. The following are, for example, some of the results obtained, the curves having been plotted with a uniform rate of heating corresponding with the attainment of 950 deg. in 90 minutes.

		Length in Millimetres of the step in the Curve corresponding with the Ac1 point.
Steel with 1·2 per cent. carbon (initially coalesced)	1st curve	21·5
	2nd ,,	22·5
Steel with 0·98 per cent. carbon (initially coalesced)	1st curve	22·5
	2nd ,,	25·5
Case-hardened iron with 0·70 per cent. carbon	1st curve	18·5
	2nd ,,	23·5
	3rd ,,	23·5
Case-hardened iron with 1·45 per cent. carbon	1st curve	21·0
	2nd ,,	25·0
	3rd ,,	25·0

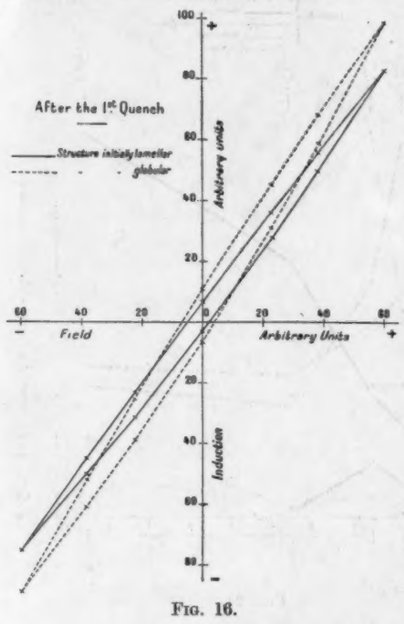

FIG. 16.

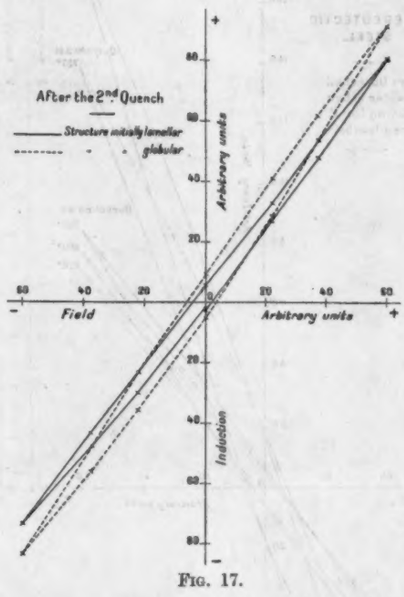

FIG. 17.

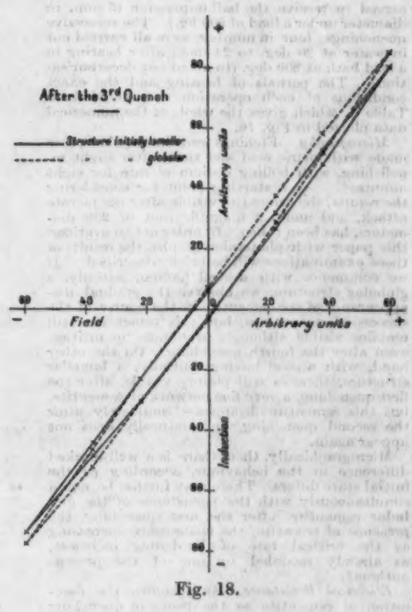

FIG. 18.

TABLE I. INFLUENCE OF THE ANTECEDENT STRUCTURAL CONDITION ON THE PROPERTIES AFTER QUENCHING.

Antecedent Structural State.	Conditions of Heat Treatment. No. of Quenchings.	Duration of Heating before Quenching.	Total Duration of the Heating Periods Undergone by the Test-Pieces.	Temperature of the Lead Bath. Original.	Final.	Temperature of the Water.	Diameter of the Ball Impression (Diameter, 5 mm.; Load, 500 kg.) Millimetres.	Resistivity in Microhm Centimetres.	Magnetism* (Arbitrary Units). Maximum Intensity of the Magnetisation.	Remanence.
				deg.	deg.	deg.				
Lamellar	First quenching	45 sec.	45 sec.	800	798	23	1·02	32·07	83·0	6·5
Globular	First quenching	45 sec.	45 sec.	803	798	23	1·16	29·77	98·5	11·0
Lamellar	Second quenching	45 sec.	90 sec.	800	804	24	0·99	35·60	81·0	6·5
Globular	Second quenching	45 sec.	90 sec.	807	802	24	1·27	30·40	91·5	9·5
Lamellar	Third quenching	2 min.	3 min. 30 sec.	800	800	24	1·03	33·96	80·5	6·0
Globular	Third quenching	2 min.	3 min. 30 sec.	803	800	24	1·03	33·06	85·5	7·0
Lamellar	Fourth quenching	5 min.	8 min. 30 sec.	803	800	20	1·03†	36·27	84·0	7·0
Globular	Fourth quenching	5 min.	8 min. 30 sec.	806	800	20	1·03†	35·60	86·5	7·5

* Initial magnetic features of the test-pieces:

Lamellar structure—	
Maximum intensity of magnetisation	187·0
Remanence	28·0
Granular structure—	
Maximum intensity of magnetisation	218·5
Remanence	13·0

† Samples which cracked on quenching. Hardness measurements impossible.

Dilatometric Method.—The differential dilatometrical method with the Chevenard apparatus readily lends itself, as has been seen,* to the investigation of the solution of cementite during heating and its precipitation on cooling. The complete solution of the latter is revealed by the reversibility of the dilatation in the γ state, a dilatation which, as regards this state, is practically independent of the carbon percentage as long as the solid solution is homogeneous. The retardation of the solubility of the cementite above Ac1 on heating, and its premature precipitation below Ac1 on cooling, are manifested by a period of intense dilatability.

If, under identical conditions of heating and of cooling the dilatation diagrams be plotted for one and the same eutectoid steel in the globular state and in the lamellar state, it will be found that the premature precipitation of the cementite on cooling reveals itself in the coalesced steel (Fig. 14) whereas it does not appear in the steel in which the lamellar state has been regenerated (Fig. 15).

It is only necessary to compare the two branches, in these figures, of the cooling curves corresponding with the γ state (above the Ar1 point). It is equally possible, by operating on the same test-piece of a steel initially coalesced, to trace, under identical conditions of heating, three successive diagrams of dilatation by increasing, each time, the average rate of cooling, so as approximately to realise the lamellar state after the first dilatation, and the troostitic state after the second. It has been in this way, for example, that the authors have obtained the following results on two steels in the neighbourhood of the eutectic:—

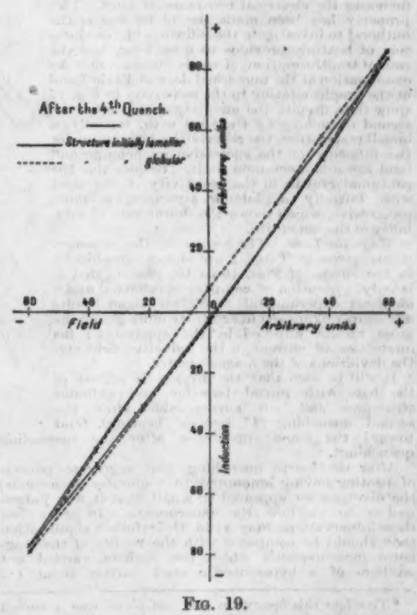

FIG. 19.

	Variations in Length corresponding with the Ac1 Transformation. 10^{-3} Mm.	
In the coalesced state	0·5	0·8
After cooling in the furnace (total period, 3½ hours)	0·9	1·2
After air cooling (total period, 20 minutes)	1·5	1·5

On the other hand, the dilatometric investigation of steels with 1 per cent. of carbon and 2 per cent. of

* A. Portevin, *Revue de Métallurgie*, 1908, vol. v, page 295.

† A. Portevin and V. Bernard, "On the Practical Determination of the Critical Points of Steel by the Differential Method," *Revue de Métallurgie*, 1919, vol. xvi, p. 175.

* A. Portevin and P. Chevenard, *Comptes Rendus*, 1921, vol. clxxii, page 1,490; *Revue de Métallurgie*, July, 1921.

chromium, previously softened by coalescence, yields no results of interest.

Investigation of the Variation in the Properties as the Result of Successive Hardenings of the same Steel in the Globular and in the Lamellar States respectively.—In this investigation the authors employed the same 0·98 carbon tool steel brought to the two states, globular and lamellar, by the treatments previously described, so as to obtain the structures represented in the two micrographs, Figs. 8 and 9. Starting from these two initial states, cylindrical test pieces 8 mm. in diameter and 150 mm. in length were prepared, to serve for the electrical and magnetic tests, as well as other test-pieces of the same diameters and 130 mm. long, to serve for the micrographic investigations and for the hardness tests. With this object there were made, on the latter test-pieces and previous to each quenching, a circular saw-cut, so that, by fracture, after hardening, a small cylinder could be removed*. The fracture surface of this cylinder after polishing and etching was examined microscopically and subsequently served to receive the ball impression (5 mm. in diameter under a load of 500 kg.). The successive quenchings, four in number, were all carried out in water at 20 deg. to 24 deg., after heating in a lead bath at 800 deg. (to avoid any decarburisation). The periods of heating and the exact conditions of each operation are recorded in Table I, which gives the whole of the numerical data plotted in Fig. 16.

Micrography.—Etchings were in the first place made with picric acid and then, after slight re-polishing, with boiling sodium picrate for eight minutes†. As a starting point for considering the results, the cementite visible after the picrate attack, and under a magnification of 200 diameters, has been taken. In order not to overload this paper with photomicrographs, the results of these examinations will be briefly described. If we commence with a steel having, initially, a globular structure, we observe the gradual disappearance of the cementite in the course of the successive quenchings, but this cementite still remains visible although in minute quantities, even after the fourth quenching. On the other hand, with a steel having, initially, a lamellar structure, there is still plainly visible, after the first quenching, a very fine network of cementite, but this cementite disappears completely after the second quenching, and naturally does not appear again.

Micrographically, then, there is a well-marked difference in the behaviour, according as the initial state differs. There may further be noted simultaneously with the persistence of the globular cementite, after the first quenching, the presence of troostite, the coalescence increasing as the critical rate of hardening increases, as already recorded by one of the present authors‡.

Electrical Resistance.—As is known, the dissolution of cementite as the result of quenching increases the electrical resistance of steel. This property has been made use of by one of the authors§ to investigate the influence of the duration of heating, previous to quenching, and the rate of transformation of steels on heating. An examination of the numerical data of Table I and of the graphs relating to the resistivity in Fig. 17 show that, despite the anomaly shown after the second quenching by the steel with, initially, a lamellar structure, the resistivities increase under the influence of the successive quenchings and tend towards a common limit. Besides this the continual growth in the resistivity of the steel with, initially, a globular structure, is more progressive, which shows the slower rate of solubility of the cementite.

Magnetic Tests.—The results of the measurements given in Table I are shown graphically in the curves of Figs. 16 to 19. Seeing that it is only a question of comparisons effected under identical experimental conditions these results are simply expressed in arbitrary units giving the gross results afforded by the apparatus; the intensities of current in the inductive field and the deviations of the magnetometer.

It will be seen that the hysteresis curves of the bars with initial lamellar and globular structures and not superposable after the second quenching (45 seconds' heating), tend toward the same appearance after the succeeding quenchings.

After the fourth quenching (the aggregate periods of heating having amounted to 8 minutes 30 seconds) the divergencies appeared so small that it was judged useless to continue the experiments. In order that these observations may yield their fullest signification they should be compared with the results of the magnetic measurements which the authors carried out on bars of a hypereutectic steel (carbon about 1·2 per cent.), quenched at increasing temperatures. These measurements, construed in the light of the hysteresis curves in Fig. 20 show that the inductions and the remanences decrease in proportion as the temperature of quenching increases, that is to say, in proportion as the quantity of cementite dissolved before quenching increases (Fig. 21).

From the foregoing it will be seen that:—(*a*) A bar with a lamellar structure should give lower induction and remanence than a bar with a globular structure when both are examined in the hardened state, starting from the same temperature and undergoing the same periods of heating; (*b*) for the requisite period of heating before quenching the divergencies between the magnetic characteristics of the two bars should counterbalance each other. That this is so is clearly brought out in the

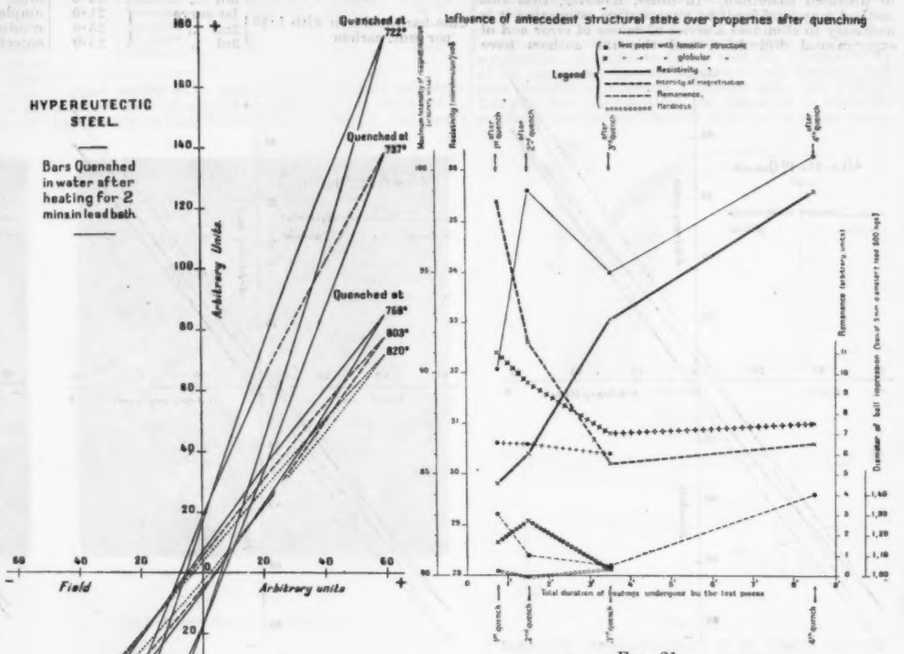

FIG. 21.

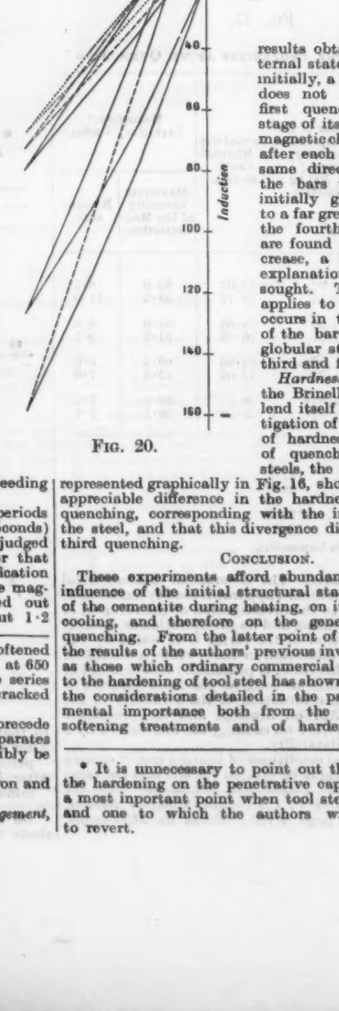

FIG. 20.

results obtained; (*c*) the internal state of the bar with, initially, a lamellar structure does not attain, after the first quenching, the final stage of its development; its magnetic characteristics vary, after each quenching, in the same direction as those of the bars with a structure initially globular, although to a far greater extent. After the fourth quenching they are found appreciably to increase, a fact of which an explanation is yet to be sought. The same remark applies to the change that occurs in the characteristics of the bar with an initially globular structure after the third and fourth quenchings.

Hardness Tests.—Although the Brinell method does not lend itself well to the investigation of very high degrees of hardness, such as those of quenched hyper-eutectic steels, the results in Table I, represented graphically in Fig. 16, show that there is an appreciable difference in the hardness after the first quenching, corresponding with the initial structure of the steel, and that this divergence disappears after the third quenching.

CONCLUSION.

These experiments afford abundant evidence of the influence of the initial structural state on the solution of the cementite during heating, on its precipitation on cooling, and therefore on the general result of the quenching. From the latter point of view they confirm the results of the authors' previous investigations as well as those which ordinary commercial practice in regard to the hardening of tool steel has shown; in this instance the considerations detailed in the paper are of fundamental importance both from the point of view of softening treatments and of hardening treatments*.

The hardening treatment of a steel cannot be entirely conditioned by a knowledge of its complete chemical composition, and of the object it is sought to attain. It depends equally on the initial structural state of the steel. The employment of coalesced hypereutectic steels conduces to modify the types of heat treatment, or to necessitate increasing the quenchings. This peculiarity constitutes an inconvenience for manufacturers of tool which is not always taken into account, but which should be considered side by side with the incontestable advantage afforded by using highly carburised and highly softened steels for machining (carbon over 1 per cent. and hardness lower than Brinell 180).

The difficulty of defining the state of coalescence of a given steel has rendered it, in the authors' opinion, useless for the moment to undertake detailed investigations as a whole. It is possible by a suitable regenerative treatment to restore a uniform structural state to steels so that the heat treatment need no longer be a function of the chemical composition. Hence arises the advantage of preliminary heat treatments with the object of putting the steel into the most favourable state to ensure maximum success for the results of the ultimate heat treatment

These preliminary heat treatments may be carried out with totally different objects and notably:—(*a*) In the present instance of hypereutectic steels, with the object of destroying the coalescence of the cementite so as to obtain, in the ensuing heating, an easier solution of the cementite and the very rapid homogeneisation of the carbon in the solid solution; (*b*) in the case of soft and some hard steels as cast (or superheated) to secure a preliminary chemical homogeneisation of the different elements in solution, as has been shown by the important investigations carried out by Giolitti*; (*c*) in the case of soft superheated steels in order to refine the grain, as for example, in the regenerative treatment before quenching of case-hardened parts.

Such varying objects can only with difficulty be attained by a generalised heat treatment of the kind known as normalisation; the methods should be varied in accordance with the results sought.

To sum up, there are in principle, and having regard to the most ordinary instances, only two solutions of the problem of heat treatment of a steel of given chemical composition:—(1) To take into account in laying down the conditions of the final heat treatment the existing structural state of the steel; and (2) to adopt a uniform heat treatment based on the chemical composition of the steel by 'preparing" the latter, that is to say, by previously inducing in it a structural condition, which shall always be constant, by means of a preliminary heat treatment adapted to the antecedent heat treatment history of the steel.

In regard to the latter solution, which is the best, the final heat treatment must be entirely defined—according to the object of the nature of the parts to be treated—by the characteristic curves of the steels†. With identical values for the magnetic field, the inductions and remanences are always higher in the case of steels with an initial globular structure than in the case of those with an initial lamellar structure.

* To effect this operation the test-piece was softened by tempering for two minutes in a bath of lead at 650 deg. If all the cuts had been made before the series of treatments the bars, thus notched, might have cracked on quenching.

† As Whiteley points out, it is preferable to precede the picrate attack by a picric acid attack which separates the cementite from the ferrite, which might possibly be spread over it by the subsequent polishing action.

‡ A. Portevin and M. Garvin, Journal of the Iron and Steel Institute, 1919, No. 1, p. 559.

§ A. Portevin, *Bulletin de la Societe d'Encouragement*, 1914, vol. cxxi, page 207.

* It is unnecessary to point out the reflex action of the hardening on the penetrative capacity of the steel, a most important point when tool steels are concerned, and one to which the authors will have occasion to revert.

* F. Giolitti, "The Preliminary Heat Treatment of Soft and Some Hard Steels for Machine Construction." Paris, Dunod, 1920.

† See A. Portevin and P. Chevenard on this subject, ENGINEERING, vol. cxii, page 551.